SPATIAL VARIATIONS IN ENERGY ACCESSIBILITY IN THE SOVIET UNION, 1960-1975

by

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The emphasis in coal, oil, and natural gas production in the Soviet Union [redacted] shifted dramatically eastward after 1960, but spatial patterns of energy accessibility remained fairly stable from 1960 to 1975. Utilizing annual coal, oil, and natural gas production data expressed in terms of standard fuel units and distances measured along railroad and pipeline routes, an energy potential model permitted the computation of energy potential indices based on distance and distance modified by generalized transport costs for

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129 major administrative and industrial centers for 1960, 1970, and 1975. A general purpose contouring program mapped relative energy potential indices, and these maps showed that the areas with the highest energy accessibility [redacted] were also among the most important industrial areas. A correlation analysis between energy accessibility and urban population growth revealed that changes in energy accessibility have had a modest influence on urban population growth rates. Soviet industrial location and urban population growth have been relatively unrestrained by the location of energy resources.

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CHAPTER I

INTRODUCTION

Background

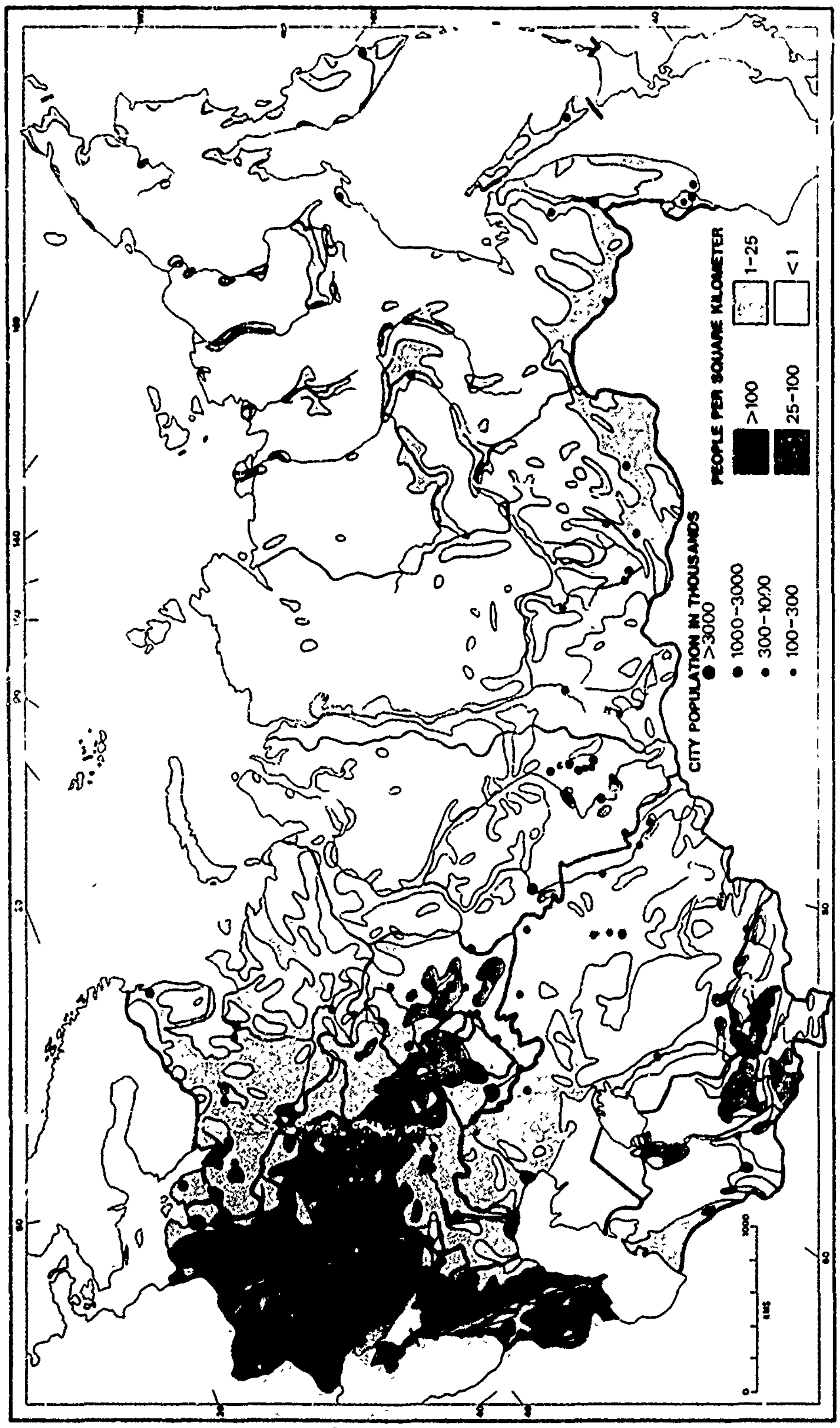
The Soviet Union is the only large industrialized country in the world to be completely self-sufficient in energy resources at the present and for the foreseeable future (Lydolph 1979, p. 261). Although the Soviet Union has imported natural gas from its neighbors to the south, Iran and Afghanistan (Ebel 1978, p. 165, Lydolph 1979, p. 280), and some coal from Poland (Lydolph 1979, p. 288), these imports reflect the uneven spatial distribution of energy resources within the U.S.S.R. and the desire of the Soviets to minimize transportation costs in providing energy to outlying areas of the country. In fact, the Soviet Union is a net exporter of coal, oil, and gas with oil being its primary hard currency earning export. It is largely through the export of energy resources that the Soviets have been able to gain the hard currency with which they have purchased the large quantities of feed grain needed to maintain livestock herds at levels sufficient to placate the desires of the Soviet consumer for more meat. This hard currency is also used to obtain the high technology items which the U.S.S.R. is either unable or unwilling to produce itself due to production bottlenecks inherent in its centrally planned economy.

Even more important than their current position as major export items has been the use of energy resources to fuel the boilers of Soviet industry and thus provide the foundation upon which the steady growth of Soviet GNP during the past three decades has depended (Lydolph 1979, pp. 199-200; Cohn 1970). Dienes (1978) has demonstrated the uniqueness of the high level of energy intensity of Soviet economic development, and Dewdney (1976) has stated that "among the many factors that have favoured the industrial growth of the Soviet Union, none has been more important than that country's possession, within its own borders, of vast energy resources of all types" (p. 62). Unfortunately for the Soviets, "there is a striking lack of coincidence between the location of most of this industrial energy and the present centres of consumption" (Hooson 1966, p. 81). Three-fourths of the population and four-fifths of the industry of the Soviet Union are found in the European portion of the country, including the Urals and the Caucasus, while as much as 90% of the estimated energy reserves, including hydroelectricity, are located east of the Urals and the Caspian Sea (Dienes 1971).

When Soviet industrial energy needs were much more modest than they are now, adequate energy resources were easily accessible in locations favorably situated in the so-called "fertile triangle" of the country where most of the population is located (Figure 1.1). The Soviet Union possesses vast reserves of energy resources, but, as Hardt (1973) so aptly paraphrased Khruschev, "the U.S.S.R. cannot fire its diesels with statistics" (p. 27). Consequently, the Soviets have been forced to search elsewhere for new sources of energy. The spatial distribution of energy resources within the Soviet Union has resulted in the exploitation of coal, oil, and gas fields that are far removed from the population

FIGURE 1.1

Source: Lydolph (1979, p. 156)


CITY POPULATION IN THOUSANDS
>3000
1000–3000
300–1000
100–300
PEOPLE PER SQUARE KILOMETER
>100
25–100
1–25
<1

and industrial centers of the country. Examples of this include increased production at the coal basins of Pechora, Kansk-Achinsk, and Ekibastuz, as well as the discovery of the supergiant oil and gas fields of Tyumen Oblast in Western Siberia (Figure 1.2). The further burdening of an already overtaxed railroad network and the building of oil and gas pipelines have been necessary to make these energy resources accessible to the bulk of Soviet energy consumers.

Problem Statement

As the emphasis of Soviet energy production shifted eastward and links were built to make this energy available for use to the urban and industrial consuming centers of the European U.S.S.R., certain areas and nodes (industrial and administrative centers) have undoubtedly undergone significant changes (absolute and relative in comparison to other areas and nodes) in accessibility to energy. The purpose of this study is to examine the changes in energy accessibility in the Soviet Union through the use of an energy potential model and to determine what influences these changes might have had on urban growth and industrial location. The aim of this research is not to explain all the complex factors involved in Soviet urban growth and industrial location but only to investigate the interrelationship between energy accessibility on the one hand and urban growth and industrial location on the other.

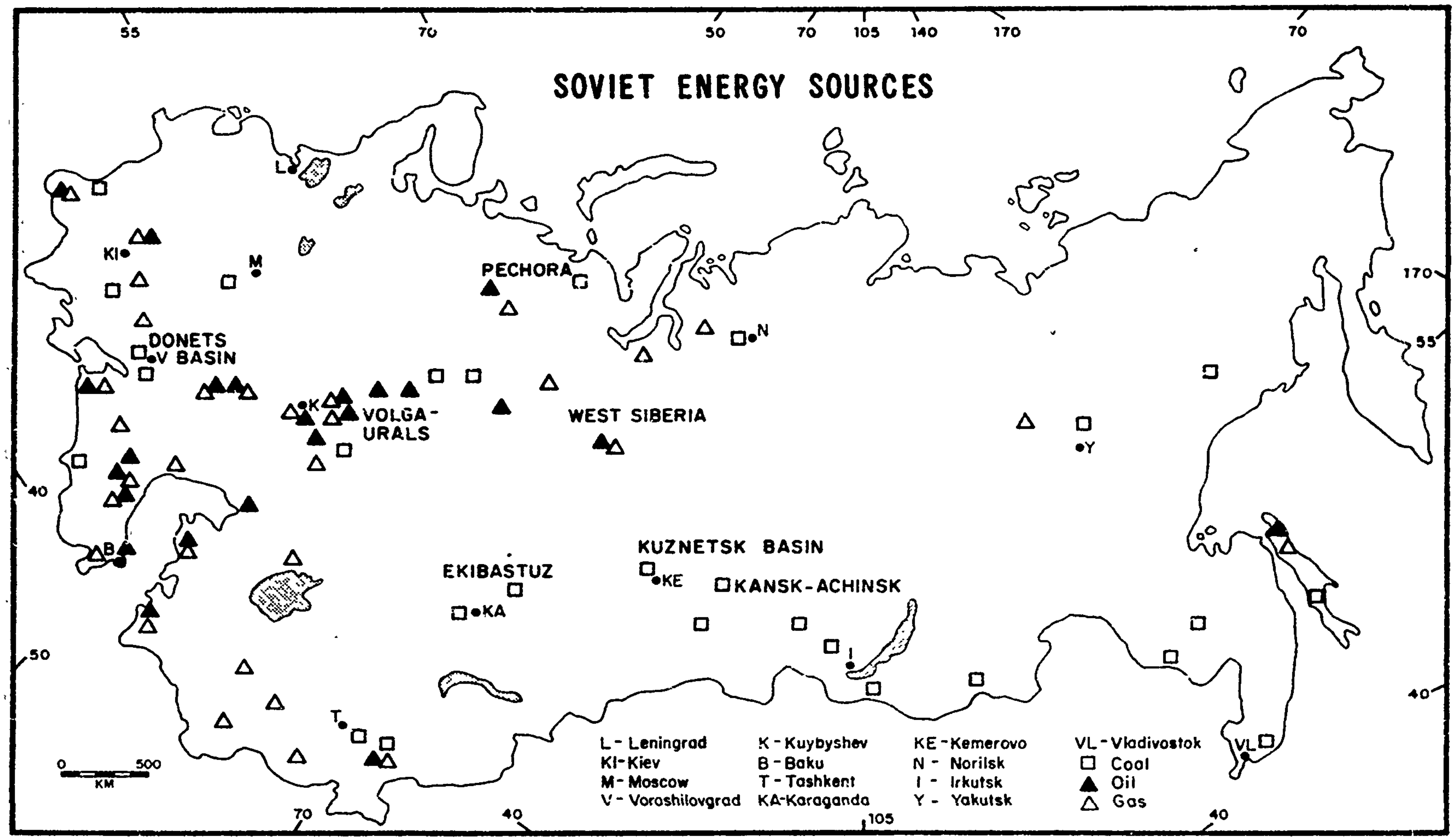
Energy accessibility will be determined for 129 nodes, and energy potential maps of the Soviet Union will be compiled for the years 1960, 1970, and 1975. Only coal, oil, and gas will be used in this study. Peat, oil shale, firewood, and electricity from hydroelectric and nuclear power plants can be very important on a local level but contribute little

FIGURE 1.2

Source: Data for outline and cities taken from <u>Soviet Union</u>

National Geographic Society, 1976,

transverse polyconic projection


SOVIET ENERGY SOURCES
PECHORA
DONETS
V BASIN
VOLGA-
URALS
WEST SIBERIA
EKIBASTUZ
KUZNETSK BASIN
KANSK-ACHINSK
L - Leningrad
KI - Kiev
M - Moscow
V - Voroshilovgrad
K - Kuybyshev
B - Baku
T - Tashkent
KA - Karaganda
KE - Kemerovo
N - Norilsk
I - Irkutsk
Y - Yakutsk
VL - Vladivostok
Coal
Oil
Gas
0 500
KM

on a national basis. The three major types of energy together accounted for 89.2, 92.1, and 93.6 percentage of total Soviet production for the years 1960, 1970, and 1975 respectively (Dienes and Shabad 1979, pp. 32-34).

Research Objectives

This study will attempt to provide answers to the following central research questions.

1. How can energy accessibility be measured through the use of a potential model?

2. What have been the changing patterns of energy accessibility in the Soviet Union? How has energy accessibility in the Soviet Union changed during the study period?

3. How do spatial patterns of energy accessibility correspond with industrial areas in the Soviet Union?

4. What is the relationship between energy accessibility and urban growth?

5. If energy accessibility has been an important factor in urban growth and industrial location, has its importance been increasing or decreasing? Is it likely to be an important factor in the future?

Outline of Chapter Contents

Chapter II reviews major studies dealing with Soviet urban growth, industrial location, and natural resources. Specifically, it summarizes factors influencing Soviet urban growth, socialist principles of industrial location, links between resources and industrial output, links between industrial output and urban population, and the use of potential

models. Methodology is the theme of Chapter III, which discusses the selection of the data points and the types of energy and describes the energy potential model, the compilation of the data matrices, and the development of the energy potential maps. Chapter IV analyzes the data assembled in Chapter III in an effort to determine and evaluate whatever links may exist between energy accessibility on the one hand and urban growth and industrial location on the other. A summary of findings and the implications of this study are presented in Chapter V.

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CHAPTER II

LITERATURE REVIEW

Introduction

This research has been undertaken in an effort to determine patterns of energy accessibility in the Soviet Union and to assess the significance of energy accessibility on urban growth and industrial location. The literature dealing with Soviet urban growth, industrial distribution, and natural resources is quite diverse, and this chapter reviews the published literature relevant to the establishment of links between urban population, industrial location, and natural resources, particularly energy. In order to place the relationship between energy accessibility and urban growth in proper perspective, it is necessary to summarize the many factors influencing urban growth and industrial location and to demonstrate how urban population can be used as a surrogate measure of industrial distribution. There are five sections in this review. The first three cover Soviet urban growth, industrial location, and natural resources. The fourth reviews uses of potential models, and the last section is a summary.

Urban Growth

In their study of Russian and Soviet urbanization, Lewis and Rowland (1969) asserted that "the growth of Soviet cities is the most

visible geographic change that has occurred in the U.S.S.R." (p. 776). Their definition of urbanization had two applications (Lewis and Rowland 1969, p. 779). Level of urbanization referred to the percentage of total population living in centers with a population of at least 15,000, and change in urbanization was the absolute change in the level of urbanization. Although they analyzed urbanization in terms of industrialization, transportation accessibility, and in-migration, they felt that urban population growth was so obviously the most important factor in urbanization that it was unnecessary to test the relationship. In some parts of their study, they even used urban population as an index of urbanization (Lewis and Rowland, 1969, pp. 779, 782, 785, and 789).

To determine national and regional patterns of urbanization, data for population centers of 50,000 and over were aggregated at the economic region level for the period 1959-1966 (Data were not available for centers under 50,000 for that period, but centers of 50,000 and over accounted for 76 percent urban population). During 1959-1966, the Donets-Dnepr, Central Chernozem, Volga-Vyatka, Northwest, and Belorussia regions exhibited the greatest increase in urbanization, and the most rapid urban growth occurred in Moldavia, Central Asia, Kazakhstan, Belorussia, and the Central Chernozem regions (Lewis and Rowland 1969, p. 789).

A rank correlation analysis of the effect of industrialization (as measured by the percentage of the total population in manufacturing) on urbanization (as measured by the percentage of the total population classified as urban) showed that between 1926 and 1961 industrialization was a significant factor (.05 level) in promoting the "city-forming process," with a Spearman rank correlation coefficient of +0.794. The level of urbanization in 1959 had a rank correlation of +0.828 with the

percentage of the total population in manufacturing in 1961 (Lewis and Rowland 1969, p. 791). Further analysis revealed that industrialization was more significant in stimulating the growth of large cities with a population of over 100,000 ($r = +0.766$) than of small ones ($r = +0.609$) for the period 1926-1961. The authors also mentioned that large cities produced 70-75% of Soviet gross industrial production (Lewis and Rowland 1969, p. 792). Transportation accessibility and in-migration were also noted as important factors in Russian and Soviet urbanization (Lewis and Rowland 1969, pp. 792-795).

Harris (1971) examined the growth of Soviet urban population between 1959 and 1970. At the regional level, variations in urban population growth were due primarily to the different stages each region had reached in the urban and demographic revolutions. "The urban revolution is marked by high rates of urban growth sustained by a massive rural-urban migration," and "the demographic revolution is characterized by falling death rates and falling birth rates but at different times" (Harris 1971, pp. 102-103). He stated that "among the major economic regions, variations in the rate of increase in urban population are inversely related to the proportion of the population urban, are positively connected with rate of natural increase in population, and are negatively associated with change in level of rural population" (Harris 1971, p. 110).

At the oblast level, high urban growth rates were associated with a low percentage of population urban, as in Rovno and Belgorod oblasts, in the Ukraine and the RSFSR, respectively, or with a high rate of natural increase, as in Guryev oblast in Kazakhstan and oblasts in Soviet Central Asia. A number of urban districts that had experienced the most

rapid urban growth during 1926-1939 displayed low urban growth rates during 1959-1970 (20 percent or less compared to the national average of 36 percent). These included Donetsk and Voroshilovgrad oblasts in the Donbas area, Tula oblast in the Moscow Coal Basin, and Kemerovo oblast in the Kuzbas region, all of which were heavily dependent on the coal industry "which has suffered from the competition of rapidly expanding petroleum and natural gas production" (Harris 1971, p. 116). Petroleum and natural gas discoveries helped account for rapid urban growth in oblasts in Soviet Central Asia, western Kazakhstan, and Western Siberia.

Of the 221 cities with 100,00 or more population in 1970, Harris (1971) briefly examined the growth of 28 cities with high growth rates (over 75 percent) and six cities with population decreases since 1959. Of the 28 cities with high growth rates, 16 were industrial cities, and 12 were diversified political-administrative centers. Of the 16 industrial cities, seven were associated with chemical industries, four with hydroelectric projects, three with iron and steel mills, and two with other industries. Of the seven industrial cities with chemical industries, Novgorod, Grodno, Rovno, and Cherkassy were old cities with fuel deficiencies that had had slow growth rates stimulated by the piping-in of natural gas (Harris 1971, p. 119). The six cities which showed population declines during 1959-1970 were coal-mining cities in the Donbas, Kuzbas, and Chelyabinsk coal basin (Harris 1971, p. 122-123).

A similar study by Lydolph and Pease (1972) found that during the period 1939-1959, most cities from the Volga eastward experienced high growth rates with particularly high rates for coal mining towns, while western cities grew less rapidly (Lydolph and Pease 1972, p. 252). This pattern of growth generally reversed itself during 1959-1970, and the

growth rate and absolute declines of coal mining centers across the country reflected the declining importance of coal in the Soviet energy mixture (Lydolph and Pease 1972, pp. 252-255). These declines give substance to the statement that "trends in industrialization are intimately related to trends in city growth" (Lydolph and Pease 1972, p. 252).

Lydolph and Pease (1972) felt that the growing importance of oil and natural gas would smooth the way for the location of industries in the western heavily populated areas. They wrote:

> The discovery and exploitation of huge deposits of oil and gas in such remote regions as Western Siberia and the Mangyshlak Peninsula of Central Asia will bring boom times to these areas and will produce a few workers' settlements of considerable size, but these energy sources will be removed from their regions of origin for consumption elsewhere and will not provide an impetus for widespread settlement of these empty areas. Western Siberia's anticipated role as producer of one-third of all Soviet oil in 1980 will have its primary impact not on potential changes within the region itself, but rather on its contribution to total Soviet energy production, the increased supplies of easily transported fluid fuels, permitting the establishment of people-oriented industries serving the labor and markets of the Soviet West (Lydolph and Pease 1972, p. 261).

Urbanization continued unabated during the 1970-1979 intercensal period, and patterns of urban growth corresponded closely with those of the 1959-1970 period (Lydolph _et al_. 1978, p. 525; Bond and Lydolph 1979, pp. 461-475). The growth rates of most cities with populations over 100,000 declined from the 1959-1970 period, but this seemed "to be related more to stages of development than to geographical location" (Lydolph _et al_. 1978, p. 528). Although "no universally applicable axiom emerges relating magnitudes of growth to city functions" (Bond and Lydolph 1979, p. 471), diversified political-administrative centers, such as Minsk and Yerevan, had moderate and steady annual growth rates, and industrial cities displayed both the highest and the lowest growth

rates. The industrial cities with the highest growth rates were based on automotive activities along the Kama and Volga, oil and gas exploitation in West Siberia, and, in one case, the construction of a new iron and steel industry in the Kursk Magnetic Anomaly area. Cities with low or negative growth rates were in older industrial areas, such as coal mining centers in the Donets and Kuznetsk basins and metallurgical areas in the Urals (Bond and Lydolph 1979, pp. 471-475).

Urban growth and industrialization have been closely linked throughout the Soviet period. Prior to 1959, the eastern part of the country experienced high urban growth rates, especially coal mining areas including those in the western part of the country. During the intercensal periods 1959-1970 and 1970-1979, the western cities grew at a faster rate than did the eastern cities, but the annual growth rates were generally lower for all cities during the 1970-1979 period. Cities in Soviet Central Asia and the Transcaucasus exhibited high growth rates during both periods because of their initial low levels of urbanization and high natural population increase. The impact of the changing nature of the energy mixture was demonstrated by the low growth rates or population declines of coal mining cities during 1959-1970 and 1970-1979 while some cities had slow growth stimulated by the piping-in of natural gas. Oil and gas were expected to have more impact on the nation as a whole than on the producing regions.

Industrial Location

Although Western literature on Soviet industrial location is replete with references to Soviet location theory, Rodgers (1974) has observed that "no distinctive and coherent body of ideas than can

legitimately be called 'socialist location theory' has been produced in the U.S.S.R. or in any other socialist state" (p. 235). It is possible though to identify the following general Soviet industrial planning goals or principles (Huzinec 1977; Koropeckyj 1970; Lonsdale 1961; Lydolph and Pease 1972; Rodgers 1974):

1. Locate industry close to sources of raw materials and to markets in order to minimize transport costs.

2. Plan regional industrial development to make all regions as economically self-sufficient as possible.

3. Promote regional specialization to take advantage of favorable conditions and to utilize natural resources most effectively.

4. Raise the level of development of the underdeveloped regions of the country to that of the most advanced.

5. Eliminate the socioeconomic differences between rural and urban areas by distributing industry throughout the country.

6. Create and maintain the greatest possible capacity for defense.

Several of these objectives are incompatible or mutually exclusive, and the emphasis placed on them has shifted through time. These principles have often been used as justification for decisions made for pragmatic or political reasons. This is especially true as Soviet planners have wrestled with the problems of:

> development of well-populated, industrially underdeveloped regions; rejuvenation or diversification of old industrial areas with the attraction of growth industries; and integration of harsh pioneer areas, rich in natural resources, into the mainstream of the country's economic life (Dienes 1971, p. 27; Dienes 1972, p. 437).

Studies have endeavored to detect motives behind regional economic development which might reveal adherence to one or more of the planning

principles. Dienes (1972) examined the rate of capital return and marginal capital product in Soviet industry during the 1960s and found that "regional investment allocation evidently was guided by strategic considerations" (p. 446) because "the under-industrialized western regions, where capital and labor productivity are satisfactory or high, have been slighted in favor of more easterly provinces" (p. 437).

In his study of Soviet industrial location policy, Koropeckyj (1970) noted the concentration of industry in large cities and the importance of large cities in total industrial output. Soviet writers were then bemoaning "the excessive concentration of industrial development primarily in large and major cities" (Mikhailov and Solovev 1969, p. 130). Manufacturing plants were attracted to cities because labor and capital productivity were generally higher in such locations. Advances in technology tended to occur more rapidly in urban areas. These factors contributed to the location of industry in Soviet cities and the growth of cities during the 1960s (Koropeckyj 1970, pp. 280-284). Koropeckyj concluded by pointing out that no single principle dominated Soviet industrial location policy and that among all the forces at work the most important one was probably the one which reflected the political interests of the ruling group (Koropeckyj 1970, p. 285). This conclusion was supported by Abouchar (1979) who stated that "no single broad social or economic policy emerges . . . behind the pattern of attained and planned industrial growth rates since 1965" (p. 102).

Rodgers (1974) used average numbers of industrial production personnel on a region scale (generally oblast and autonomous republic level with some union republic data) to reveal shifts of industry in the U.S.S.R. 1940-1955 and 1955-1965. In 1940, there was a high correlation

($r^2 = 0.75$) between the distribution of urban population and industrial employment (Rodgers 1974, p. 229). The German invasion of World War II was largely responsible for a general eastward shift of industry between 1950 and 1955 (Rodgers 1974, pp. 233-235). The shifts between 1955 and 1965 were more complex with no single area of industrial expansion. The areas with the highest growth were the Baltic republics, Belorussia, Moldavia, the Ukraine, the northern and western Caucasus, and the middle and lower Volga Valley (Rodgers 1974, p. 235).

Thinking that the reasons behind the 1955-1965 patterns might have been connected with regional variations in energy production, Rodgers (1974) calculated fuel and power output by region for 1965 and regressed those values on the shifts in industrial employment with results that were statistically insignificant. Rodgers argued that these results reflected the shift in emphasis from coal to oil and gas, whose relative ease of movement permitted a "high degree of locational freedom" (Rodgers 1974, p. 237). To test the relationship between changes in industrial location and the distribution of markets, population distribution for 1965 was used as a surrogate measure for markets, and the correlation between the regional population values and the shifts in industrial employment was "quite strong" ($r^2 = 0.42$). An R^2 of 0.46 resulted from a multiple regression with the 1955-1965 shifts in industrial employment as the dependent variable and population and fuel outputs for 1965 as the independent variables (Rodgers 1974, p. 237). This further underscored that the role of energy was less important than might otherwise have been expected in industrial location.

Additional analyses revealed that "there was remarkably limited evidence of the implementation of the equality principle" (Rodgers 1974,

p. 238). Rodgers (1974) concluded that "if there is a conscious regional planning policy in the U.S.S.R., it appears to support growth rather than equity" (p. 238). This observation was also noted by Fuchs and Demko (1979) who wrote that continued spatial inequalities in socialist states "can be explained in terms of the priority placed on efficiency or military security as opposed to equity in industrial location decisions" (p. 304).

The principles of industrial location ascribed to socialist planners are somewhat contradictory, and no clear guiding principle has emerged although military considerations and growth appear to be the most important factors. Industry is concentrated in large cities, and industrial growth has been highest in the western regions of the country in recent years. Markets were much more important than energy production in changes in industrial location.

Natural Resources

"The study of the role of natural resources in the location of the economy and population has been an important and traditional research area in economic geography" (Runova 1976, p. 73). Mints and Kakhanovskaya (1974) developed a generalized resource potential index in an effort to quantitatively assess the natural resource potential of regions in the U.S.S.R. The natural resources included in their study were coal, oil, natural gas, iron ore, hydroelectric resources, timber resources, arable land, natural forage, and other major resources, such as chemical raw materials or nonferrous metals if particularly significant for a given region. The areal units for which data were available were union republics, krays, oblasts, and autonomous republics (Mints and

Kakhanovskaya 1974, pp. 556-557). The resource data were converted to annual productivity indicators. In the case of mineral resources, reserves were divided by the estimated periods of extraction. Additionally, reserve estimates were limited to those likely to be accessible in the next ten to 15 years. Once annual productivity indicators were determined, they were expressed in monetary units using rounded current prices, and the values were then arithmetically manipulated to determine the resource potential of each region (Mints and Kakhanovskaya 1974, pp. 559-561). The prices chosen for their calculations are probably the most controversial part of their study, considering the complex and often irrational pricing system of centrally planned economies.

The values were replaced with percentages to show the relative contribution of each resource to the rescurce potential of a region and each region to the total national potential. The results were somewhat startling, showing that the European part of the country (including the Urals) accounted for more than 40% of the nation's total potential, whereas Siberia and the Far East accounted for only 33%. This was due largely to the way values for mineral reserves were calculated and to the significant role of agriculture which represented 69% of the total resource potential in Kazakhstan, 65% in the European south, 64% in the middle and northern latitudes of the European U.S.S.R., and 61% in Soviet Central Asia. In Siberia and the Far East, agriculture accounted for only around 15% of total resource potential (Mints and Kakhanovskaya 1974, p. 561).

A choropleth map of resource density by unit area showed high values for southern agricultural areas, particularly those with significant mineral and hydroelectric resources. A map of resource availability

on a per capita basis showed high values for the eastern regions (Mints and Kakhanovskaya 1974, pp. 562-563). Mints and Kakhanovskaya (1974) felt that "the results obtained and the maps compiled on that basis may already be useful in small-scale research on regional-planning and resource-use problems covering the Soviet Union as a whole or some of its major regions" (p. 556).

In a later study, Mints (1976) stated that "the resource factor plays a steadily declining role in shaping the spatial structure of the economy as a whole" (p. 9), in part, because of advances in transportation technology which make it easier to transport energy and raw materials (Mints 1976, p. 10). Although West Siberia is rich in oil and gas reserves, such reserves should be considered part of the energy base of the European part of the U.S.S.R., because the hostile environment precludes the establishment of local processing industries in areas as the West Siberian gas fields (Mints 1976, p. 12). Mints (1976) observed that recent trends to locate oil refineries in market areas are expected to continue (p. 15) and that "the existing spatial distribution of population and current migration trends are likely to become key factors in industrial location" (p. 21). His statement refers to the availability of labor in the western regions where most of the markets are, the continuous labor shortage in Siberia and the eastern regions, and the lack of success with inducing labor to stay in labor-short areas.

Using the resource potential data determined by Mints and Kakhanovskaya (1974), Runova (1976) examined the links between the distribution of resources, economic activity, and population at the economic region level. The results of a linear correlation analysis on a pairwise basis showed that the correlations were extremely low between resources

as a whole and the distribution of total economic output (r = +0.02) and between resources and total population (r = +0.04). The correlations between industrial resources and industrial output and between industrial resources and urban population were also quite low (r = +0.03 for both relationships). There was a strong relationship (r = +0.96) between the distribution of industrial output and urban population. The difficulty of working with data at the economic region level was underscored when the great centers of production (the Central Region) and of resources (West Siberia) were omitted from the analysis. The correlations between total resources and total economic output (r = +0.43) and for total resources and population (r = +0.65) were then much higher (Runova 1976, pp. 83-85).

Dienes examined Soviet energy policy and regional development (Dienes 1971) and the problems of allocation in the Soviet fuel supply (Dienes 1973). Both studies were concerned with the concept of marginal fuel costs and the regional allocation of energy resources. A linear programming solution yielded an optimal fuel mix for each region (Dienes 1971, pp. 45-48; Dienes 1973, pp. 9-14). This linear programming solution was followed by a discussion of the heated debates between the "pro-Siberian" planners who wanted to severely curtail industrial location west of the Urals and the "pro-European" planners who had chafed under the relatively slow development of western mineral reserves, such as the Kursk Magnetic Anomaly (Dienes 1971, pp. 49-56; Dienes 1973, pp. 16-20). Dienes felt that resistance to a strongly pro-Siberian energy-oriented investment policy would grow because "taking workers and industry to energy sources has proved less effective than hoped for, and Soviet

planners are learning what Adam Smith knew: 'Of all baggage, people are the most expensive to move'" (Dienes 1971, pp. 57-58).

Efforts to quantify natural resource potential have been largely descriptive and highly aggregated. The relationship between resources on the one hand and industrial output and urban population on the other was rather weak, but the relationship between the distribution of industrial production and urban population was quite strong. The importance of resources as a factor in industrial location is expected to decline because of advances in transportation technology. The harsh environment of the eastern regions and the availability of labor in the western region is expected to further encourage the location of industry in the western market areas.

Potential Models

Although the concept of potential models has been criticized (Houston 1969; Taaffe and Gauthier 1973, pp. 97-99; Yeates 1974, pp. 130-131), potential models have been widely used as macrogeographic tools by human geographers in a variety of ways. Some of their uses have been to construct potential maps showing possible interactions between people or between producers and markets, to discover empirical regularities in the distribution of population, and to analyze patterns of transport costs and the effects of highway location on such patterns (Lukermann and Porter 1960; Stewart and Warntz 1958; Taaffe and Gauthier 1973, pp. 90-92). This section reviews some uses of potential models which are particularly relevant to this study.

Harris (1954) pioneered the use of potential models and maps constructed from them when he examined the importance of market accessibility

as a factor in industrial location in the United States. He calculated an index of accessibility to markets with a market potential model using the formula, $P = \Sigma\left(\frac{M}{d}\right)$, where P = the market potential for a given city, M = county retail sales, and d = straight line distance as modified by a generalized estimate of freight rates. Two assumptions underlay this model. One was that county retail sales provided a good measure of the overall market for goods, and the other was that straight line distances measured from a map could be used instead of actual route distances because of the dense transportation network of the United States (Harris 1954, pp. 316-323).

New York City was found to have the highest market potential, and utilizing the values of the other cities in his study expressed as a percentage below New York City, Harris (1954) drew an isarithmic market potential map of the United States with contours representing lines of equal market potential. Harris (1954) relied on visual inspection to show how closely the area with the highest market potential coincided with the American Manufacturing Belt (Harris 1954, pp. 323-326).

Fifteen years later, Houston (1969) compiled several market potential maps of the Soviet Union employing total population, urban population, and total population weighted by retail sales per capita by republic as measures of market size. Distances between the 128 points used in calculating market potential indices were shortest rail and/or rail-ferry distances instead of straight line distances because of the nature of the Soviet transportation network which is a great deal less dense than that of the United States (Houston 1969, pp. 218-220). Since he was concerned primarily with an analysis of the concept of potential models, Houston (1969) made no interpretation of their application to

the U.S.S.R., but the market potential generally matched population distribution and was highest around Moscow.

In his monograph, Cities of the Soviet Union, Harris (1970) determined population potential indices for the entire country and compiled potential maps based on total, rural, and urban population. Harris (1970) used population by oblasts or similar administrative units and direct airline distances between the geographical centers of the oblasts at which the entire population was considered to be concentrated (Harris 1970, p. 187). Harris (1970) stated that urban population potential "measures on a country-wide basis and in a highly generalized and abstract form many elements of industrial location: market, labor, industrial materials for complex industries, and of the interaccessibility of such elements" (p. 194).

Summary

Soviet urban growth has been highest in the Soviet West, Transcaucasia, and Central Asia and has been affected primarily by trends in industrialization and stages in the urban and demographic revolutions. Although no single principle has been dominant, Soviet industrial location policy has appeared to favor maximizing national economic growth and defense considerations. The pull of markets and the availability of labor apparently have been strong factors in industrial location and have resulted in the concentration of industrial production in large cities in the western regions of the country. Analyses have shown the relationship between the distribution of urban population and industrial output to be quite strong.

Urban population and industrial distribution are inextricably linked in the U.S.S.R., but not much effort has been made to link urban and industrial growth to accessibility to energy, except for occasional comments on the impact of energy on the growth of individual cities or clusters of cities. Those studies which sought to examine the relationship of energy on the one hand and the distribution of urban population and industrial production on the other attained results that were surprisingly low. These low results were probably due to the fact that they were not considering the availability of energy. Rather, the energy data were in a highly aggregated form either as regional energy production data or submerged in regional industrial resource data. No one has examined nationwide patterns of energy accessibility, and the links between urban growth and energy accessibility have not been rigorously tested on a macrogeographic basis. Any link which can be established between urban growth and energy accessibility will provide additional information on the nature of Soviet urban-industrial growth policies.

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CHAPTER III

DATA AND METHODOLOGY

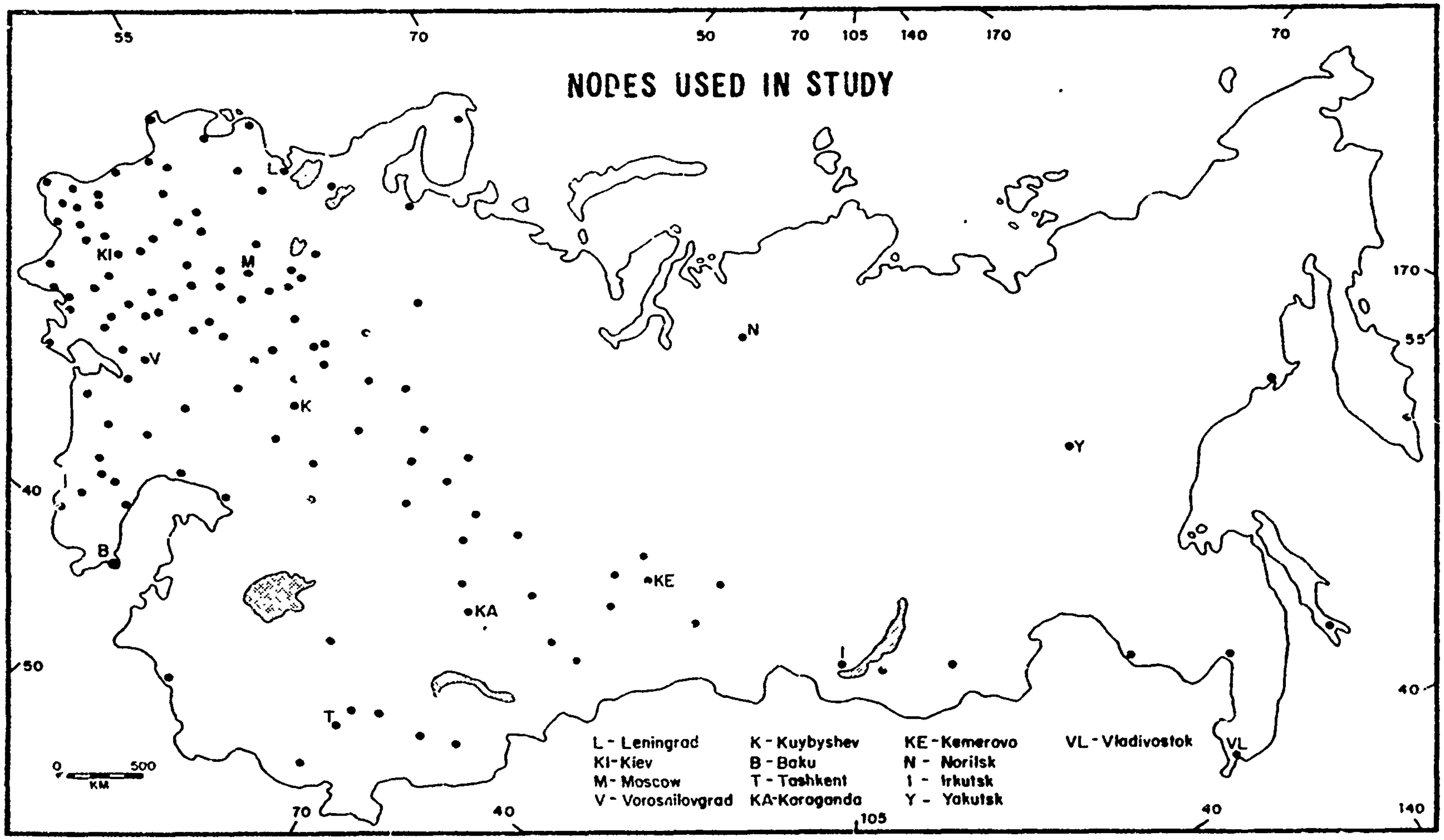
Introduction

This chapter deals with how energy accessibility was determined for 129 cities of the Soviet Union. This introductory section discusses the selection of the nodes, years, and types of energy used in this study. Five sections follow. The first describes an energy potential model used to calculate energy accessibility. The next two sections cover the computation of energy production data and the measurement of distances needed in the energy potential model. The last section presents the energy potential indices and map compilations.

For the purpose of determining the patterns of energy accessibility in the Soviet Union, 129 nodes were selected (Figure 3.1). These nodes are cities which are either union republic capitals or centers of autonomous republics, oblasts, or krays (except for Norilsk). Although they do not include all of the almost 200 capitals or administrative centers of the country, they do provide adequate coverage of the ecumene of the Soviet Union and represent almost half of the 272 cities with populations of 100,000 or over in 1979. In addition to being administrative centers, many, if not most, of these 129 cities are also industrial cities. Large cities were selected in favor of smaller cities because census data for them were readily available.

FIGURE 3.1

Source: Data for outline and cities taken from Soviet Union, National Geographic Society, 1976, transverse polyconic projection



NODES USED IN STUDY

Only coal, oil, and natural gas were used in this study. Shale oil, peat, firewood, and hydroelectric and nuclear power plans can be very important on a local level but contribute little on a national basis. As can be seen from Table 3.1, the three major types of energy together accounted for 89.2, 92.1, and 93.6 percentage of total soviet energy production for the years 1960, 1970, and 1975 respectively. Considering the nearly ubiquitous availability of firewood, this omits only a small portion of the total Soviet energy production mixture.

The years 1960, 1970, and 1975 were selected for study because they are reasonably close to the census years of 1959, 1970, and 1979. It would have been preferable to use a year closer to 1979 than 1975, but, in 1977, the Soviet government imposed a virtual lid of secrecy on the publication of regional production data for coal, oil, and natural gas (Shabad 1978; Shabad 1979). This affected data for 1976 as well, and consequently, 1975 is the last year for which energy production data in a disaggregate form are available.

An Energy Potential Model

Energy potential indices were calculated using:

$$EP_i = \sum_{j=1}^{n} \frac{AP_j}{d_{ij}}$$

where EP_i = energy potential of a city

AP_i = annual production of an energy source expressed in standard fuel units, and

d_{ij} = distance from an energy source to a city as measured along rail routes for coal, rail and pipeline for oil, and pipeline for natural gas.

Exponents of one were applied to each AP_j and d_{ij}. Actual route distances were used in computations rather than straight line distances

Table 3.1

Soviet Energy Production, in Million Metric Tons of Standard Fuel[a] and Percentage of Total

	1950		1960		1970		1975	
Type of Energy	Production	%	Production	%	Production	%	Production	%
Petroleum	54.2	17.0	211.4	29.5	502.5	39.6	701.9	43.3
Natural gas	7.3	2.3	54.4	7.6	233.5	18.4	342.9	21.2
Coal and lignite	205.7	64.5	373.1	52.1	432.7	34.1	471.8	29.1
Peat	14.8	4.6	20.4	2.8	17.7	1.4	18.5	1.1
Oil shale	1.3	0.4	4.8	0.7	8.8	0.7	10.8	0.6
Firewood	27.9	8.8	28.7	4.0	26.6	2.1	25.4	1.6
Hydroelectricity	7.5	2.4	23.8	3.3	45.6	3.6	42.8	2.6
Nuclear power	--	--	--	--	1.3	0.1	6.9	0.4
Total[b]	318.7	100	716.6	100	1268.7	100	1621.0	99.9

[a] One ton of SF (standard fuel) is equal to seven million kilocalories.

[b] Percent totals may not equal exactly 100% due to rounding.

Sources: Dienes and Shabad (1979, pp. 32-34) and Lydolph (1979, p. 262).

in order to make the results more realistic. Energy potential indices were calculated using both route distances and route distances modified by estimated transport costs.

Energy Production Data

Before energy production data could be entered into the energy potential model, two tasks had to be performed with the available regional energy production data. First, the data had to be disaggregated from regional data to point data in order to have energy source points from which to measure distance to the cities under study. Because the spatial distribution of energy production is not homogeneous within regions, the geographic center of each region for which energy data were available could not be used as the energy source point for that region. Instead, the selection of points for energy sources was based on an examination of the locations of energy producing fields within each region, and the actual positions of the energy source centers were determined by the distribution of coal, oil, and natural gas fields within a region. The sources consulted in the determination of the energy source point and the points themselves are contained in the appropriate production data tables (Tables 3.2, 3.3, and 3.4).

The other task involved the standardizing of coal, oil, and natural gas production data by converting them into standard fuel units. The term standard fuel (or conventional fuel) is often employed by the Soviets for comparing different forms of energy. Standard fuel has a heat content of 7,000 kilocalories per kilogram (Ebel 1970, p. xix; Elliot 1974, p. 266), and conversion factors may be applied to the various types of fuel to obtain standard fuel equivalents.

Table 3.2

Regional Distribution of Soviet Coal Production
(in Million Metric Tons of Standard Fuel)

Region	1960	1970	1975	XSF[a]	Center[b]
Pechora Basin	17.4	20.0	21.8	0.90	Vorkuta-Inta
Moscow Basin	17.9	14.2	13.0	0.38	Tula
Donets Basin					
Rostov	26.4	24.9	24.5	0.75	Shakhty
Ukraine	128.7	142.1	141.8	0.75	Gorlovka
Lvov-Volhynia	3.9	10.3	11.7	0.81	Chervonograd
Dneper Basin	3.3	2.8	3.2	0.25	Aleksandriya
Georgia	1.9	1.4	1.3	0.61	Kutaisi
Bashkir	1.1	2.1	2.7	0.29	Kamertau
Perm	11.9	8.0	6.1	0.90	Kizel
Sverdlovsk	6.5	5.2	2.9	0.29	Serov
Chelyabinsk	10.7	9.2	8.2	0.43	Korkino
Kuznetsk Basin	69.0	87.3	102.8	0.75	Kemerovo
Kansk-Achinsk	4.5	9.0	13.4	0.48	Krasnoyarsk
Chernogorsk[c]	3.1	4.1	3.7	0.75	Abakan
Norilsk[c]	1.9	2.5	2.2	0.70	Norilsk
Cheremkhovo	12.1	12.1	10.2	0.73	Cheremkhovo
Azey	0.4	2.7	4.3	0.43	Tulun
Buryat	0.4	0.6	0.6	0.43	Gusinoozersk
Chita	2.6	2.9	5.2	0.70	Karymskoye
Yakut	0.7	1.1	1.4	0.70	Yakutsk
Amur	4.1	5.5	5.8	0.43	Raychikhinsk
Khabarovsk	0.7	0.9	1.1	0.71	Urgal
Maritime	5.0	6.5	7.1	0.70	Artem
Sakhalin	3.5	3.4	3.5	0.70	Uglegorsk
Magadan	0.9	1.0	1.5	0.80	Kadykchan
Karaganda	22.7	31.6	37.0	0.80	Karaganda
Ekibastuz	4.0	14.0	27.5	0.60	Ekibastuz
Uzbekistan	2.2	2.3	3.2	0.61	Angren
Fergana[d]	3.0	2.9	3.0	0.61	Andizhan
Total	370.5	430.6	470.7	0.67	

[a]Factors used to convert 1975 raw production data into standard fuel units. These values were multiplied by 1.03 and 1.10 to obtain factors for 1970 and 1960 respectively.

[b]Distances were measured from these energy source centers to the nodes under study.

[c]Estimates based on 1965 production.

[d]Represents the combined production of the Kirghiz and Tadzhik SSRs.

Sources: Dienes and Shabad (1979); Elliot (1974); Hodgkins (1961); Lydolph (1977); Lydolph (1970); Shabad (1969).

Table 3.3

Regional Distribution of Soviet Oil Production
(in Million Metric Tons of Standard Fuel)

Region	1960[a]	1970[a]	1975[a]	Center[b]
Komi	1.2	10.9	15.7	Pechora
Krasnodar	10.0	8.4	8.9	Krasnodar
Stavropol	2.3	9.2	10.0	Neftekumsk
Chechen-Ingush	4.7	28.6	12.9	Groznyy
Dagestan	0.3	3.1	2.9	Makhachkala
Tatar	66.2	145.7	148.3	Almetyevsk
Bashkir	36.2	56.1	55.9	Tuymazy
Kuybyshev	31.5	50.0	49.8	Kuybyshev
Saratov[c]	2.9	1.9	1.9	Saratov
Volgograd[c]	7.2	10.0	9.6	Zhirnovsk
Perm	3.3	23.0	31.9	Perm
Orenburg	1.7	10.6	19.9	Pokrovka
Udmurt	h	0.7	4.9	Sarapul
Belorussia	h	6.0	11.4	Rechitsa
West Ukraine[d]	3.1	4.0	2.7	Dolina
East Ukraine[d]	h	15.9	15.6	Gadyach
Azerbaijan	25.5	28.9	24.6	Baku
Tyumen				
Shaim	h	6.0	7.2	Shaim
Samotlor[e]	h	34.0	197.3	Megion
Tomsk[e]	h	4.9	7.2	Strezhevoy
Sakhalin	2.3	3.6	3.4	Okha
Kazakhstan				
Emba	2.2	3.9	5.4	Makat-Dossor
Mangyshlak	h	14.9	28.7	Uzen
Fergana Valley[f]	3.0	3.3	2.7	Andizhan
Turkmenia	7.6	20.7	22.3	Nebit Dag
Georgia[g]	h	h	0.4	
Total	211.2	504.3	701.5	

[a]A factor of 1.43 was used to convert raw regional production data into standard fuel units.

[b]Distances were measured from these energy source centers to the nodes under study.

[c]Estimates for 1970 and 1975 based on 1960 and 1965 data.

[d]Estimates based on relative contribution to total Ukrainian production.

[e]Combined into one source with center near Megion when determining distances to nodes.

[f]Represents the combined production of the Uzbek, Kirghiz, and Tadzhik SSRs.

[g]Not used because contribution to any node's energy potential was so slight.

Table 3.3--Continued

[h]Negligible or no production.

Sources: Campbell (1968); Dienes and Shabad (1979); Ebel (1961); Ebel (1970); Elliot (1974); Lydolph (1977); Lydolph (1979); Lydolph and Shabad (1960); Shabad (1969).

Table 3.4

Regional Distribution of Soviet Natural Gas Production
(in Million Metric Tons of Standard Fuel)

Region	1960[a]	1970[a]	1975[a]	Center[b]
Komi	1.2[e]	8.1	22.0	Vuktyl
Krasnodar	6.1	29.1	9.4	Tikhoretsk
Stavropol	9.8	19.4	13.6	Stavropol
Chechen-Ingush	0.4	5.0	4.2	Groznyy
Dagestan[d]	0.1	1.9	1.2	Makhachkala
Tatar	1.7	4.6	5.2	Almetyevsk
Bashkir	1.6[d]	2.2	1.7	Belebey
Kuybyshev	1.2[d]	2.7	2.5	Kuybyshev
Saratov	3.0	4.0	1.2	Saratov
Volgograd	3.1	4.7	3.6	Kotovo
Astrakhan[d]	f	0.9	0.6	Astrakhan
Perm	f	1.1	1.3	Perm
Orenburg	0.6[d]	1.5[d]	23.9	Orenburg
Azerbaijan	7.0[d]	6.5	11.8	Baku
West Ukraine	6.2	14.4	8.2	Borislav
East Ukraine	11.0	57.4	73.6	Shebelinka
Belorussia[e]	f	0.2	0.7	Rechitsa
Tyumen				
Punga-Igrim	f	10.9	4.3	Punga-Igrim
Medvezhye	f	f	35.1[d]	NE of Nadym
Ob oil gas	f	0.1[c]	2.6[d]	Samotlor
Norilsk[d]	f	0.5	3.1	Messoyakha
Yakut[d]	f	0.2	0.6	Tas-Tumus
Sakhalin[c]	0.4	0.9	1.2	Okha
Kazakhstan				
Bazay	f	1.8[c]	1.8	Bazaz
Uzen	f	0.7[c]	4.4	Uzen
Uzbekistan	0.5[c]	37.8	44.3	Gazli
Turkmenia				
West Turkmen	0.3[c]	1.6[c]	3.6	Kum-Dag
North Turkmen	f	11.6[d]	36.7	Achak
South Turkmen	f	2.4[d]	21.4	Mary
Kirghizia[c]	f	0.4	0.3[e]	
Tadzhikistan	f	0.5[d]	0.5[e]	Dushanbe
Total	54.2	233.1	344.6	

[a]Factors to convert raw regional production data into standard fuel units were 1.20 for 1960, 1.18 for 1970, and 1.19 for 1975.

[b]Distances were measured from these energy source centers to the nodes under study.

[c]Not used because of lack of transportation link to any node in this study.

Table 3.4--Continued

[d]Applied only to local nodes because of lack of access to nationwide network.

[e]Not used because contribution to any particular node's energy potential was negligible.

[f]Negligible or no production.

Sources: Campbell (1968); Dienes and Shabad (1979); Ebel (1970); Elliot (1974); Lydolph (1977); Lydolph (1979); Lydolph and Shabad (1960); Shabad (1969).

The quality and caloric value of Soviet coal varies tremendously between regions. In 1975, a ton of hard coal (anthracite and bituminous) ranged from 0.57 to 0.93 ton of standard fuel and lignite or brown coal from 0.29 to 0.57 ton of standard fuel. The average heat content of a ton of Soviet coal has declined slightly over time from 0.73 ton of standard fuel in 1960, 0.69 ton in 1970, to 0.67 ton in 1975 (Dienes and Shabad 1979, pp. 32-33, 110-111). This decline meant that the factors needed to convert raw coal production data into standard fuel units (Table 3.2) varied not only by region but also through time. Regional conversion factors were first obtained for 1975 from several sources (Dienes and Shabad 1979; Elliot 1974; Lydolph 1979; Shabad 1969). If a precise conversion factor could not be found for a coal basin, an estimate was made based on the description of the type and quality of the coal and the range of values for hard and brown coal. Because the average heat content of Soviet coal has declined through time, the regional conversion factors for 1975 were multiplied by 1.03 to obtain values for 1970 factors and 1.10 for 1960. These conversion factors, when applied to the raw production data, gave totals (Table 3.2) that were fairly close to the actual aggregated production figures for coal in terms of standard fuel (Table 3.1).

Oil and natural gas also vary somewhat in quality (such as paraffin content for oil and sulfur content for natural gas), but their heat content is sufficiently uniform among regions that one conversion factor was used for all regions when transforming raw regional production data into standard fuel units (Table 3.3 for oil; Table 3.4 for gas). The conversion factors for oil and natural gas were calculated by dividing total standardized production (in standard fuel units) for each (Dienes

and Shabad 1979, p. 32) by total raw production for each (Dienes and Shabad 1979, pp. 46 and 70). A ton of oil had a heat content equivalent to 1.43 tons of standard fuel in 1975, and this value was also used for 1970 and 1960. The heat value of 1000 cubic meters of natural gas in 1975 was approximately 1.19 tons of standard fuel, and this value varied only slightly over time with values of 1.18 for 1970 and 1.20 for 1960.

The eastward shift in Soviet energy production is evident in all three major fuels. The Kuznetsk, Kansk-Achinsk, Karaganda, and Ekibastuz basins have all greatly expanded their output since 1960 (Table 3.2). The oil fields of the Volga-Urals area, including the Tatar and Bashkir ASSRs, and Kuybyshev, Perm, and Orenburg oblasts, more than doubled their combined production from 1960 to 1970, while the Baku oil fields' production remained stagnant. Almost 800 kilometers east of the Urals, the newly developed middle-Ob oil fields of Tyumen Oblast were the largest single source of energy in the Soviet Union in 1975 (Table 3.3). The shifts in gas production were rather erratic (Table 3.4). The North Caucasus gas fields of Krasnodar and Stavropol krays were up sharply in production in 1970 from 1960 and down in 1975, while the eastern Ukraine gas fields experienced dramatic increases in production from 1960 to 1970 and 1975. Similar increases occurred in Orenburg and Tyumen oblasts, Uzbekistan, and Turkmenia. The Komi ASSR in the northeastern part of the Northwest economic region achieved substantial increases in oil and gas production and a modest increase in production at its Pechora coal basin from 1960 to 1975. These production trends suggest that the patterns of energy potential will be somewhat different from those of population or market potential and will shift eastward through time.

Distance Measurement

After the regional energy production data had been converted into standard fuel units and assigned to a specific point within each region, it was necessary to measure the distances from each of the coal, oil, and gas source points to each of the 128 cities (Norilsk was treated as a closed system. Its energy accessibility was determined by the coal and natural gas which were available to it in its immediate area.). The basic unit of distance measurement was 100 kilometers because of the great distances involved in working with the Soviet Union and also because of the degree of generalization already effected by assignment of regional data to points. For those nodes located at or within 150 kilometers of an energy source point, the distance was recorded as one unit.

The shortest distances along rail and rail-ferry routes were determined between the 128 cities and 29 coal sources. Houston greatly facilitated what still proved to be a laborious and time-consuming task by graciously supplying the railroad distance matrix he used in his study of market potential surface patterns in the Soviet Union (Houston 1969). Marine and river transport routes were not considered except for Yuzhno-Sakhalinsk, Magadan, Yakutsk, and Petropavlovsk-Kamchatskiy. This was not a serious omission because almost all coal in the Soviet Union is transported by rail with marine and river shipments never accounting for more than 4% of total coal loadings during the period of this study (Elliot 1974, p. 173; Lydolph 1979, p. 421). The basic pattern of the Soviet rail network remained virtually unchanged from 1960 to 1975, and the distance matrix tabulated for 1960 required only slight modifications for use in 1970 and 1975 (Appendix A). The Soviets completed rail

links between Astrakhan and Guryev on the north shore of the Caspian Sea in 1967, Makat and Beyneu along the northeast edge of the Caspian Depression in 1965, and Beyneu and Kungrad across the Ust-Urt Plateau in 1970 (Lydolph 1977, p. 330; Yonge 1975). These added rail links had an appreciable effect on the distances for only four cities--Astrakhan, Volgograd, Guryev, and Aktyubinsk.

Distances between the oil sources and 128 cities were measured along the shortest pipeline, rail, and rail-ferry routes. River and marine tankers engaged in domestic trade carried only 6% of crude oil shipments in 1960, while pipelines and railroad tanker cars handled 72% and 22% respectively. The share carried by pipelines has increased since 1960, and that of rail and tankers has decreased (Dienes and Shabad 1979, pp. 62-63). It was possible to obtain actual lengths, general locations, and dates of completion of major pipelines from a number of sources (Campbell 1968; Dienes and Shabad 1979; Ebel 1961; Ebel 1970; Elliot 1974; Fullard 1965; Fullard 1972; Hassmann 1953; Hodgkins 1961; Kish 1960; Kish 1970; Lydolph 1977; Lydolph 1979; Lydolph and Shabad 1960; National Geographic Society 1976; Shabad 1961b; Shabad 1969; Taaffe and Kingsbury 1965). Pipelines were generally built parallel to rail lines, and their distances were often similar (Table 3.5). This similarity meant that if actual oil pipeline lengths were unknown adjusted rail distances could be used. If no rail link existed between two points connected by a pipeline, the pipeline distance was estimated. The similarity between pipeline and rail distances also meant that only relatively minor changes had to be made in the distance matrices (Appendix B) to reflect the expansion of the oil pipeline network from 1960

Table 3.5

Comparison of Selected Oil Pipeline and Rail Distances

Origin	Terminus	Length (km)	Rail Distance (km)
Omsk	Irkutsk	2470	2475
Omsk	Chita	3500	3488
Tuymazy	Leningrad	1500	1800
Kuybyshev	Mozyr	1350	1700
Unecha	Polotsk	375	445
Polotsk	Klaipeda	475	550
Polotsk	Ventspils	475	551
Kuybyshev	Bryansk	1185	1318
Omsk	Pavlodar	420	664
Gorkiy	Ryazan	415	634
Michurinsk	Kremenchug	700	869
Ryazan	Moscow	250	197

Sources: Ebel (1961, p. 149); Houston (1969); USSR Geological Ministry (1966); Yonge (1975).

to 1975. The major changes in the distance matrices consisted of bringing new oil sources into the transportation network.

Natural gas travels only by pipeline in the Soviet Union, and all cities did not have access to the natural gas pipeline network. Forty-two of the cities in this study had access to natural gas in 1960, 90 in 1970, and 94 in 1975. The distance matrices for natural gas (Appendix C) were derived in the same manner as for oil with respect to pipeline locations, construction dates, and lengths (Sources the same as for oil plus Shabad 1961a). The distance matrices for natural gas changed significantly from 1960 to 1975 as new gas fields were brought into production, the natural gas pipeline network expanded, and additional cities gained access to the network.

Energy Potential: Indices and Maps

Coal, oil, and natural gas potential indices for 1960, 1970, and 1975 were calculated for each city (Appendix D) by an SAS matrix algebra problem (Helwig and Council 1979) using the previously determined energy production and distance data. These indices were added together to give total energy potential indices for 1960, 1970 and 1975 (Table 3.6), and the highest energy potential index for each year was divided into the others for that year to give relative measures of energy accessibility (Table 3.6). The same procedure was followed to arrive at total energy potential indices based on transport costs (Table 3.7). A generalized transport cost ratio of 5:1:4 was used to represent estimated transport costs for coal, oil, and natural gas (Campbell 1968, p. 211; Dienes and Shabad 1979, p. 43 note 45 and p. 236 note 41; Elliot 1975, p. 271).

Table 3.6

Energy Accessibility Based on Distance

NODE	TEP60[a]	TEP70[a]	TEP75[a]	REP60[b]	REP70[b]	REP75[b]
LENINGRAD	30	54	65	16	21	24
MURMANSK	19	29	35	10	11	13
PETROZAVODSK	25	39	46	14	15	17
NOVGOROD	32	58	69	17	23	26
VOLOGDA	34	66	80	18	26	30
ARKHANGELSK	24	39	46	13	15	17
SYKTYVKAR	25	52	68	14	20	25
MOSCOW	51	86	99	28	33	37
YAROSLAVL	38	73	88	21	28	33
VLADIMIR	43	84	97	23	33	36
IVANOVO	39	78	91	21	30	34
KALININ	41	72	85	22	28	32
KALUGA	57	89	101	31	35	38
KOSTROMA	37	72	87	20	28	32
RYAZAN	50	85	99	27	33	37
TULA	61	96	107	33	37	40
KAZAN	76	148	158	41	58	62
GORKIY	48	89	105	26	35	39
KIROV	36	62	75	20	24	29
YOSHKAR_OLA	52	104	123	28	40	46
SARANSK	52	91	109	28	35	41
CHEBOKSARY	58	108	126	32	42	47
ULYANOVSK	68	119	133	37	46	49
BELGOROD	67	127	144	36	49	54
VORONEZH	58	104	118	32	40	44
KURSK	56	101	114	30	39	42
OREL	52	92	104	28	36	39
BRYANSK	49	86	100	27	33	37
LIPETSK	52	96	108	28	37	40
TAMBOV	51	91	103	28	35	38
PENZA	57	99	116	31	39	43
ASTRAKHAN	40	69	76	22	27	28
VOLGOGRAD	62	98	114	34	38	42
KUYBYSHEV	95	177	206	52	69	77
SARATOV	69	114	133	38	44	49
ROSTOV	126	195	187	68	76	70
KRASNODAR	66	121	113	36	47	42
STAVROPOL	62	110	111	34	43	41
MAKHACHKALA	40	75	73	22	29	27
NALCHIK	42	92	93	23	36	35
ORDZHONIKIDZE	49	108	102	27	42	39
GROZNYY	49	111	104	27	43	39
KIEV	44	92	105	24	36	39
ZAPOROZHYE	67	119	132	36	46	49
KHARKOV	84	169	193	46	66	72
LVOV	41	79	83	22	31	31
KISHINEV	30	59	68	16	23	25
TALLIN	26	48	58	14	19	22
RIGA	25	49	60	14	19	22
VILNIUS	28	54	65	15	21	24
KALININGRAD	24	37	44	13	14	16
SMOLENSK	37	73	86	20	28	32
PSKOV	28	44	52	15	17	19
MINSK	34	61	76	18	24	23
TBILISI	32	62	70	17	24	26
BAKU	59	92	101	32	36	38

Table 3.6--Continued

NODE	TEP60	TEP70	TEP75	REP60	REP70	REP75
YEREVAN	26	50	58	14	19	22
LUTSK	31	65	72	17	25	27
ROVNO	32	67	75	17	26	29
UZHGOROD	28	68	70	15	26	26
IVANO_FRANKOVSK	30	73	75	16	29	23
TERNOPOL	36	70	77	20	27	29
ZHITOMIR	39	75	85	21	29	32
VINNITSA	36	70	81	20	27	30
KHMELNITSKIY	32	69	78	17	27	29
CHERNOVSTY	29	59	67	16	23	25
CHERNIGOV	40	87	103	22	34	38
SUMY	47	111	124	26	43	46
POLTAVA	59	162	186	32	63	69
CHERKASSY	51	99	111	28	39	41
KIROVOGRAD	43	63	70	23	25	25
ODESSA	34	69	79	18	27	29
NIKOLAYEV	43	83	94	23	32	35
KHERSON	43	83	94	23	32	35
SIMFEROPOL	42	60	65	23	23	24
DNEPROPETROVSK	76	133	148	41	52	55
DONETSK	164	241	254	99	94	94
VOROSHILOVGRAD	184	257	269	100	100	100
GRODNO	26	52	62	14	20	23
VITEBSK	34	53	79	18	21	29
MOGILEV	36	57	85	20	22	32
GOMEL	38	78	93	21	30	35
BREST	32	60	69	17	23	26
UFA	73	135	162	40	53	60
IZHEVSK	52	105	131	29	41	49
ORENBURG	48	84	136	26	33	51
PERM	59	124	154	32	48	57
SVERDLOVSK	41	78	106	22	30	39
CHELYABINSK	50	88	114	27	34	42
TYUMEN	33	59	82	18	23	30
KURGAN	39	65	86	21	25	32
OMSK	33	53	73	18	21	27
NOVOSIBIRSK	42	63	91	23	25	34
TOMSK	40	60	56	22	23	36
BARNAUL	33	49	70	18	19	26
KRASNOYARSK	30	47	71	16	18	26
IRKUTSK	28	37	46	15	14	17
CHITA	16	23	32	9	9	12
ABAKAN	28	43	59	15	17	22
KEMEROVO	86	118	156	47	46	58
ULAN_UDE	16	24	33	9	9	12
VLADIVOSTOK	13	19	23	7	7	9
KHABAROVSK	10	15	19	5	6	7
BLAGOVESHCHENSK	11	16	21	6	6	8
YUZHNO_SAKHALINSK	9	14	17	5	5	6
MAGADAN	8	12	15	4	5	6
YAKUTSK	10	15	19	5	6	7
PETROPAVLOVSK_KAM	7	12	14	4	5	5
GURYEV	29	72	91	15	28	34
AKTYUBINSK	37	73	95	20	28	35
URALSK	42	68	79	23	26	29
KUSTANAY	40	72	95	22	28	35

Table 3.6--Continued

NODE	TEP60	TEP70	TEP75	REP60	REP70	REP75
PETROPAVLOVSK	35	58	76	19	23	28
KOKCHETAV	32	54	71	17	21	26
TSELINOGRAD	35	57	75	19	22	28
KARAGANDA	47	72	90	26	29	33
KZYL_ORDA	24	39	48	13	15	18
CHIMKENT	23	45	60	13	19	22
DZHAMBUL	21	43	57	11	17	21
SEMIPALATINSK	24	37	50	13	14	19
PAVLODAR	32	58	86	17	23	32
UST_KAMENOGORSK	24	37	49	13	14	18
ALMA_ATA	20	39	52	11	15	19
ASHKHABAD	23	38	63	13	15	23
DUSHANBE	16	27	49	9	11	18
TASHKENT	23	47	61	13	19	23
FRUNZE	20	40	54	11	16	20
NORILSK	2	2	3	1	1	1
ELISTA	37	54	59	20	21	22

[a]Total energy potentials for 1960, 1970, and 1975 based on distance.

[b]Relative energy potentials for 1960, 1970, and 1975 as percentages of Voroshilovgrad.

Table 3.7

Energy Accessibility Based on Transport Costs

NODE	TEP60[a]	TEP70[a]	TEP75[a]	REP60[b]	REP70[b]	REP75[b]
LENINGRAD	15	31	39	19	21	24
MURMANSK	9	19	25	12	13	15
PETROZAVODSK	13	26	32	17	18	20
NOVGOROD	15	34	41	20	23	25
VOLOGDA	18	40	50	23	27	30
ARKHANGELSK	13	26	32	17	18	20
SYKTYVKAR	13	32	42	17	22	26
MOSCOW	24	48	58	31	33	35
YAROSLAVL	20	45	55	26	31	33
VLADIMIR	25	53	62	32	36	37
IVANOVO	22	49	58	29	33	35
KALININ	20	42	51	26	29	31
KALUGA	24	47	56	31	32	34
KOSTROMA	20	45	55	26	30	33
RYAZAN	25	50	59	32	34	36
TULA	25	50	58	33	34	35
KAZAN	58	121	135	75	82	82
GORKIY	29	61	72	38	41	44
KIROV	21	45	57	27	31	35
YOSHKAR_OLA	37	78	92	48	53	55
SARANSK	31	62	74	41	42	45
CHEBOKSARY	39	80	93	51	54	56
ULYANOVSK	51	101	113	66	68	68
BELGOROD	24	57	66	31	39	40
VORONEZH	25	53	61	32	36	37
KURSK	23	50	59	29	34	35
OREL	22	47	56	28	32	34
BRYANSK	21	45	55	28	31	33
LIPETSK	24	51	60	31	35	36
TAMBOV	26	54	63	34	37	38
PENZA	34	67	78	44	46	47
ASTRAKHAN	23	48	54	30	33	33
VOLGOGRAD	30	57	66	39	39	40
KUYBYSHEV	77	147	166	100	100	100
SARATOV	44	79	91	57	54	55
ROSTOV	39	71	72	50	48	43
KRASNODAR	32	58	59	42	39	36
STAVROPOL	26	51	54	34	35	33
MAKHACHKALA	24	56	54	31	38	32
NALCHIK	23	55	55	30	38	33
ORDZHONIKIDZE	26	71	62	34	48	38
GROZNYY	28	75	67	36	51	40
KIEV	18	47	55	23	32	33
ZAPOROZHYE	23	49	56	30	34	34
KHARKOV	29	67	78	37	46	47
LVOV	18	37	41	24	25	25
KISHINEV	13	30	35	17	20	21
TALLIN	13	28	35	16	19	21
RIGA	13	29	36	17	19	22
VILNIUS	14	31	38	18	21	23
KALININGRAD	12	23	30	16	16	18
SMOLENSK	18	40	49	23	27	30
PSKOV	14	29	36	19	20	22
MINSK	16	35	44	20	24	27
TBILISI	18	35	40	23	24	24
BAKU	41	66	68	53	45	41

Table 3.7--Continued

NODE	TEP60	TEP70	TEP75	REP60	REP70	REP75
YEREVAN	14	29	34	18	20	20
LUTSK	14	33	38	18	22	23
ROVNO	14	34	41	19	23	24
UZHGOROD	14	32	36	18	22	22
IVANO_FRANKOVSK	15	36	39	19	24	23
TERNOPOL	15	34	40	20	23	24
ZHITOMIR	17	38	45	22	26	27
VINNITSA	15	36	43	20	24	26
KHMELNITSKIY	14	35	41	19	24	24
CHERNOVSTY	14	30	36	19	21	22
CHERNIGOV	18	49	61	23	33	37
SUMY	20	59	67	26	40	40
POLTAVA	22	70	81	29	48	49
CHERKASSY	19	47	54	25	32	33
KIROVOGRAD	17	36	42	23	24	25
ODESSA	15	34	40	19	23	24
NIKOLAYEV	17	40	46	23	27	28
KHERSON	17	40	46	23	27	28
SIMFEROPOL	17	33	37	22	22	22
DNEPROPETROVSK	25	54	62	33	37	37
DONETSK	44	77	85	57	52	51
VOROSHILOVGRAD	48	80	88	63	55	53
GRODNO	12	29	36	16	20	21
VITEBSK	16	34	46	21	23	28
MOGILEV	17	36	50	22	25	30
GOMEL	17	44	56	22	30	33
BREST	15	32	39	19	22	23
UFA	56	109	126	72	74	76
IZHEVSK	36	79	98	47	54	59
ORENBURG	33	66	88	43	45	53
PERM	40	97	121	52	66	73
SVERDLOVSK	23	52	73	29	35	44
CHELYABINSK	27	57	75	35	39	45
TYUMEN	18	41	63	23	28	38
KURGAN	21	45	64	28	31	39
OMSK	16	33	50	21	22	30
NOVOSIBIRSK	15	29	50	19	19	30
TOMSK	14	26	57	18	18	34
BARNAUL	13	24	40	17	16	24
KRASNOYARSK	11	21	39	14	15	23
IRKUTSK	10	16	25	12	11	15
CHITA	6	12	18	8	8	11
ABAKAN	10	21	33	14	14	20
KEMEROVO	23	38	62	30	26	37
ULAN_UDE	6	13	20	8	9	12
VLADIVOSTOK	5	9	12	6	6	7
KHABAROVSK	4	9	12	6	6	7
BLAGOVESHCHENSK	5	9	13	6	6	8
YUZHNO_SAKHALINSK	3	8	11	4	5	6
MAGADAN	4	7	10	5	5	6
YAKUTSK	4	9	12	6	6	7
PETROPAVLOVSK_KAM	3	7	9	4	5	6
GURYEV	17	46	58	22	31	35
AKTYUBINSK	23	50	64	29	34	38
URALSK	26	50	61	34	34	37
KUSTANAY	22	45	61	28	31	37

Table 3.7—Continued

NODE	TEP60	TEP70	TEP75	REP60	REP70	REP75
PETROPAVLOVSK	18	38	53	24	26	32
KOKCHETAV	16	34	48	21	23	29
TSELINOGRAD	16	31	44	21	21	26
KARAGANDA	17	33	44	23	22	26
KZYL_ORDA	14	27	34	18	18	21
CHIMKENT	12	25	34	15	17	21
DZHAMBUL	11	24	32	14	16	19
SEMIPALATINSK	10	20	30	14	14	18
PAVLODAR	13	28	43	17	19	26
UST_KAMENOGORSK	10	20	29	14	14	17
ALMA_ATA	10	21	29	12	14	17
ASHKHABAD	13	27	37	17	18	22
DUSHANBE	9	17	26	11	12	16
TASHKENT	12	26	34	15	18	20
FRUNZE	10	22	31	14	15	18
NORILSK	0	0	1	1	0	0
ELISTA	18	33	37	23	23	23

[a]Total energy potentials for 1960, 1970, and 1975 based on distance.

[b]Relative energy potentials for 1960, 1970, and 1975 as percentages of Voroshilovgrad.

A Dell Foster digitizer was employed to determine the co-ordinates (X, Y) of the 129 nodes under study and the boundary of the Soviet Union using a base map with a scale of 1:10,140,000 (National Geographic Society 1976). Z-values for each node were the relative energy potential indices as calculated for distance and transport costs for 1960, 1970, and 1975. A general purpose contouring program, GPCP-II (CALCOMP 1972), and a CALCOMP drum plotter created six isarithmic energy potential maps.

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CHAPTER IV

ANALYSIS OF ENERGY ACCESSIBILITY

Introduction

This chapter analyzes the spatial patterns of energy accessibility in the Soviet Union and its effect on Soviet urban population growth. Three sections follow. The first discusses the rank ordering of the 129 nodes based on their energy potentials and describes the six energy potential maps for 1960, 1970, and 1975 based on relative energy potential values determined by distance and distance modified by transport costs. The second section presents the results of correlation analyses between energy accessibility and urban growth. The last section is a summary.

Nodal Rank Ordering and Energy Potential Maps

Three regions dominate the top positions when the 129 nodes are rank ordered by their relative energy potentials based on distance for 1960, 1970, and 1975 (Table 4.1). These regions are the eastern Ukraine (Voroshilovgrad, Donetsk, Poltava, Dnepropetrovsk, Kharkov, Zaporozhye, Sumy), the western North Caucasus region (Rostov, Krasnodar, Stavropol), and the area of the Volga-Urals oil fields (Kuybyshev, Kazan, Ufa, Saratov, Perm, Ulyanovsk). Voroshilovgrad and Donetsk occupy the top two positions throughout primarily because of their favorable positions with respect to the Donets Basin. Rostov and Kharkov are near the Donets Basin and are also close to the gas fields of the North Caucasus and

Table 4.1

Rankings by Relative Energy Potential Based on Distance

OBS[a]	NODE	REP60[b]	OBS[a]	NODE	REP70[b]	OBS[a]	NODE	REP75[b]
1	VOROSHILOVGRAD	100	1	VOROSHILOVGRAD	100	1	VOROSHILOVGRAD	100
2	DONETSK	89	2	DONETSK	94	2	DONETSK	94
3	ROSTOV	58	3	ROSTOV	76	3	KUYBYSHEV	77
4	KUYBYSHEV	52	4	KUYBYSHEV	69	4	KHARKOV	72
5	KEMEROVO	47	5	KHARKOV	66	5	ROSTOV	70
6	KHARKOV	46	6	POLTAVA	63	6	POLTAVA	69
7	KAZAN	41	7	KAZAN	58	7	KAZAN	62
8	DNEPROPETROVSK	41	8	UFA	53	8	UFA	60
9	UFA	40	9	DNEPROPETROVSK	52	9	KEMEROVO	58
10	SARATOV	38	10	BELGOROD	49	10	PERM	57
11	ULYANOVSK	37	11	PERM	48	11	DNEPROPETROVSK	55
12	BELGOROD	36	12	KRASNODAR	47	12	BELGOROD	54
13	KRASNODAR	36	13	KEMEROVO	46	13	ORENBURG	51
14	ZAPOROZHYE	36	14	ULYANOVSK	46	14	ULYANOVSK	49
15	VOLGOGRAD	34	15	ZAPOROZHYE	46	15	ZAPOROZHYE	49
16	STAVROPOL	34	16	SARATOV	44	16	SARATOV	49
17	TULA	33	17	STAVROPOL	43	17	IZHEVSK	49
18	CHEBOKSARY	32	18	GROZNYY	43	18	CHEBOKSARY	47
19	VORONEZH	32	19	SUMY	43	19	SUMY	46
20	BAKU	32	20	CHEBOKSARY	42	20	YOSHKAR_OLA	46
21	POLTAVA	32	21	ORDZHONIKIDZE	42	21	VORONEZH	44
22	PERM	32	22	IZHEVSK	41	22	PENZA	43
23	KALUGA	31	23	VORONEZH	40	23	KRASNODAR	42
24	PENZA	31	24	YOSHKAR_OLA	40	24	KURSK	42
25	KURSK	30	25	PENZA	39	25	VOLGOGRAD	42
26	MOSCOW	28	26	KURSK	39	26	CHELYABINSK	42
27	YOSHKAR_OLA	28	27	CHERKASSY	39	27	STAVROPOL	41
28	SARANSK	28	28	VOLGOGRAD	38	28	CHERKASSY	41
29	OREL	28	29	TULA	37	29	SARANSK	41
30	LIPETSK	28	30	LIPETSK	37	30	TULA	40
31	TAMBOV	28	31	BAKU	36	31	LIPETSK	40
32	CHERKASSY	28	32	OREL	36	32	GROZNYY	39
33	IZHEVSK	28	33	KIEV	36	33	OREL	39
34	RYAZAN	27	34	NALCHIK	36	34	KIEV	39
35	BRYANSK	27	35	KALUGA	35	35	GORKIY	39
36	ORDZHONIKIDZE	27	36	SARANSK	35	36	SVERDLOVSK	39
37	GROZNYY	27	37	TAMBOV	35	37	ORDZHONIKIDZE	38
38	CHELYABINSK	27	38	GORKIY	35	38	BAKU	38
39	GORKIY	26	39	CHELYABINSK	34	39	KALUGA	38
40	SUMY	26	40	CHERNIGOV	34	40	TAMBOV	38
41	ORENBURG	26	41	MOSCOW	33	41	CHERNIGOV	38
42	KARAGANDA	26	42	RYAZAN	33	42	MOSCOW	37
43	KIEV	24	43	BRYANSK	33	43	RYAZAN	37
44	VLADIMIR	23	44	ORENBURG	33	44	BRYANSK	37
45	NALCHIK	23	45	VLADIMIR	33	45	VLADIMIR	36
46	KIROVOGRAD	23	46	NIKOLAYEV	32	46	TOMSK	36
47	NIKOLAYEV	23	47	KHERSON	32	47	NALCHIK	35
48	KHERSON	23	48	LVOV	31	48	NIKOLAYEV	35
49	SIMFEROPOL	23	49	SVERDLOVSK	30	49	KHERSON	35
50	NOVOSIBIRSK	23	50	IVANOVO	30	50	GOMEL	35
51	URALSK	23	51	GOMEL	30	51	KUSTANAY	35
52	KALININ	22	52	MAKHACHKALA	29	52	AKTYUBINSK	35
53	ASTRAKHAN	22	53	ZHITOMIR	29	53	IVANOVO	34
54	MAKHACHKALA	22	54	KARAGANDA	28	54	GURYEV	34
55	LVOV	22	55	KALININ	28	55	NOVOSIBIRSK	34
56	CHERNIGOV	22	56	KUSTANAY	28	56	KARAGANDA	33

Table 4.1--Continued

OBS	NODE	REP60	OBS	NODE	REP70	OBS	NODE	REP75
57	SVERDLOVSK	22	57	YAROSLAVL	28	57	YAROSLAVL	33
58	TOMSK	22	58	KOSTROMA	28	58	ZHITOMIR	32
59	KUSTANAY	22	59	SMOLENSK	28	59	KALININ	32
60	YAROSLAVL	21	60	AKTYUBINSK	28	60	KOSTROMA	32
61	IVANOVO	21	61	IVANO_FRANKOVSK	28	61	SMOLENSK	32
62	ZHITOMIR	21	62	GURYEV	28	62	KURGAN	32
63	GOMEL	21	63	ASTRAKHAN	27	63	PAVLODAR	32
64	KURGAN	21	64	TERNOPOL	27	64	MOGILEV	32
65	KOSTROMA	20	65	VINNITSA	27	65	LVOV	31
66	KIROV	20	66	ODESSA	27	66	VINNITSA	30
67	SMOLENSK	20	67	KHMELNITSKIY	27	67	VOLOGDA	30
68	TERNOPOL	20	68	URALSK	26	68	TYUMEN	30
69	VINNITSA	20	69	VOLOGDA	26	69	TERNOPOL	29
70	MOGILEV	20	70	ROVNO	26	70	ODESSA	29
71	AKTYUBINSK	20	71	UZHGOROD	26	71	KHMELNITSKIY	29
72	ELISTA	20	72	KIROVOGRAD	25	72	URALSK	29
73	PETROPAVLOVSK	19	73	NOVOSIBIRSK	25	73	VITEBSK	29
74	TSELINOGRAD	19	74	KURGAN	25	74	IVANO_FRANKOVSK	29
75	VOLOGDA	18	75	LUTSK	25	75	ASTRAKHAN	28
76	MINSK	18	76	KIROV	24	76	ROVNO	28
77	ODESSA	18	77	MINSK	24	77	KIROV	28
78	VITEBSK	18	78	TBILISI	24	78	MINSK	28
79	TYUMEN	18	79	SIMFEROPOL	23	79	PETROPAVLOVSK	28
80	OMSK	18	80	TOMSK	23	80	TSELINOGRAD	28
81	BARNAUL	18	81	PETROPAVLOVSK	23	81	MAKHACHKALA	27
82	NOVGOROD	17	82	TYUMEN	23	82	LUTSK	27
83	TBILISI	17	83	NOVGOROD	23	83	OMSK	27
84	LUTSK	17	84	BREST	23	84	UZHGOROD	26
85	ROVNO	17	85	PAVLODAR	23	85	KIROVOGRAD	26
86	KHMELNITSKIY	17	86	KISHINEV	23	86	TBILISI	26
87	BREST	17	87	CHERNOVSTY	23	87	NOVGOROD	26
88	KOKCHETAV	17	88	MOGILEV	22	88	BREST	26
89	PAVLODAR	17	89	TSELINOGRAD	22	89	KOKCHETAV	26
90	LENINGRAD	16	90	ELISTA	21	90	BARNAUL	26
91	KISHINEV	16	91	VITEBSK	21	91	KRASNOYARSK	26
92	IVANO_FRANKOVSK	16	92	OMSK	21	92	KISHINEV	25
93	CHERNOVSTY	16	93	KOKCHETAV	21	93	CHERNOVSTY	25
94	KRASNOYARSK	16	94	LENINGRAD	21	94	SYKTYVKAR	25
95	VILNIUS	15	95	VILNIUS	21	95	SIMFEROPOL	24
96	PSKOV	15	96	SYKTYVKAR	20	96	LENINGRAD	24
97	UZHGOROD	15	97	GRODNO	20	97	VILNIUS	24
98	IRKUTSK	15	98	BARNAUL	19	98	GRODNO	23
99	ABAKAN	15	99	TALLIN	19	99	TASHKENT	23
100	GURYEV	15	100	RIGA	19	100	ASHKHABAD	23
101	PETROZAVODSK	14	101	YEREVAN	19	101	ELISTA	22
102	SYKTYVKAR	14	102	KRASNOYARSK	18	102	TALLIN	22
103	TALLIN	14	103	CHIMKENT	18	103	RIGA	22
104	RIGA	14	104	TASHKENT	18	104	YEREVAN	22
105	YEREVAN	14	105	PSKOV	17	105	CHIMKENT	22
106	GRODNO	14	106	ABAKAN	17	106	ABAKAN	22
107	ARKHANGELSK	13	107	DZHAMBUL	17	107	DZHAMBUL	21
108	KALININGRAD	13	108	FRUNZE	16	108	FRUNZE	20
109	KZYL_ORDA	13	109	PETROZAVODSK	15	109	PSKOV	19
110	CHIMKENT	13	110	ARKHANGELSK	15	110	ALMA_ATA	19
111	SEMIPALATINSK	13	111	KZYL_ORDA	15	111	SEMIPALATINSK	19
112	UST_KAMENOGORSK	13	112	ASHKHABAD	15	112	KZYL_ORDA	18

Table 4.1—Continued

OBS	NODE	REP60	OBS	NODE	REP70	OBS	NODE	REP75
113	ASHKHABAD	13	113	ALMA_ATA	15	113	UST_KAMENOGORSK	18
114	TASHKENT	13	114	IRKUTSK	14	114	DUSHANBE	18
115	DZHAMBUL	11	115	KALININGRAD	14	115	PETROZAVODSK	17
116	ALMA_ATA	11	116	SEMIPALATINSK	14	116	ARKHANGELSK	17
117	FRUNZE	11	117	UST_KAMENOGORSK	14	117	IRKUTSK	17
118	MURMANSK	10	118	MURMANSK	11	118	KALININGRAD	16
119	CHITA	9	119	DUSHANBE	11	119	MURMANSK	13
120	ULAN_UDE	9	120	CHITA	9	120	CHITA	12
121	DUSHANBE	9	121	ULAN_UDE	9	121	ULAN_UDE	12
122	VLADIVOSTOK	7	122	VLADIVOSTOK	7	122	VLADIVOSTOK	9
123	BLAGOVESHCHENSK	6	123	BLAGOVESHCHENSK	6	123	BLAGOVESHCHENSK	8
124	KHABAROVSK	5	124	KHABAROVSK	6	124	KHABAROVSK	7
125	YUZHNO_SAKHALINSK	5	125	YAKUTSK	6	125	YAKUTSK	7
126	YAKUTSK	5	126	YUZHNO_SAKHALINSK	5	126	YUZHNO_SAKHALINSK	6
127	MAGADAN	4	127	MAGADAN	5	127	MAGADAN	6
128	PETROPAVLOVSK_KAM	4	128	PETROPAVLOVSK_KAM	5	128	PETROPAVLOVSK_KAM	5
129	NORILSK	1	129	NORILSK	1	129	NORILSK	1

[a]Approximate rankings by rounded relative energy potentials. Rankings mentioned in text are by unrounded absolute energy potential indices.

[b]Relative energy potential for 1960, 1970, and 1975 as percentage of Voroshilovgrad.

eastern Ukraine respectively. Poltava's rise from 21st place in 1960 to 6th place in 1970 and 1975 was caused by the rapid increase in production of the east Ukrainian gas fields. Kuybyshev and the other cities in the Volga-Urals oil fields area owe their rankings to their proximity to oil producing sources. Kemerovo is not near any of the three regions mentioned but owes its high rankings to its location in the middle of the Kuznetsk Basin along with some contribution from the West Siberian oil fields in 1975.

A number of nodes outside major production areas showed large changes in rank from 1960 to 1975. The old oil producing center of Baku experienced an increase in its energy accessibility from 1960 to 1975 but dropped in ranking from 19th place in 1960 to 40th place in 1975. Largely because of its gas fields, Orenburg rose from 39th place in 1960 and 44th place in 1970 to 13th place in 1975. Simferopol, on the Crimean Peninsula, experienced only a modest increase in its absolute energy accessibility from 1960 to 1975, and its relative accessibility remained virtually the same, but most other nodes increased their relative energy accessibility. Simferopol, consequently, steadily declined in rank from 49th place in 1960, 80th place in 1970, to 96th place in 1975. Guryev, on the other hand, underwent proportionally substantial absolute and relative increases in energy accessibility from 1960 to 1975 and rose from 97th place in 1960, 60th place in 1970, to 54th place in 1975. The areas with the lowest energy potentials throughout the period 1960-1975 were the Baltic, Central Asia, East Siberia, Far East, and Northwest regions.

The general patterns of energy accessibility do not appear to have changed much from 1960 to 1975, and the correlations were quite high

between the balues for 1960 and 1970 (r = +0.96), 1970 and 1975 (r = +0.98), and 1960 and 1975 (r = +0.94). Practically all nodes underwent increases in energy accessibility relative to Voroshilovgrad which experienced some of the lowest percent increases in absolute energy potential during the period 1960-1975 because of the virtually stagnant, albeit high, production of the Donets Basin.

A different pattern was evident when the rankings were by relative energy accessibility based on distance modified by transport costs (Table 4.2). The low cost of transporting oil compared to coal and gas resulted in those nodes in or near oil producing areas dominating the top positions. Additional cities (Cheboksary, Izhevsk, Penza, Saransk) in or near the Volga-Urals oil fields join those nodes in that region which were among the top when rankings were by energy accessibility based on distance. Nodes in the eastern Ukraine and others, such as Kemerovo, which were dependent on coal for a large portion of their energy accessibility dropped sharply from their earlier rankings by energy accessibility based on distance. Rostov and other cities in the North Caucasus region generally declined in rankings from 1960 to 1975. Baku, whose oil production dipped slightly from 1960 to 1975, fell from 8th place in 1960 to 21st place in 1975 as oil production greatly increased in other areas of the Soviet Union. Orenburg remained in the top 20 positions during 1960-1975 because of its location near the Volga-Urals oil fields and its own gas fields. Cities in the eastern Urals region (Chelyabinsk, Sverdlovsk, Kurgan) rose in rankings from 1960 to 1975 as a result of the influence of the Volga-Urals oil fields and the newly discovered oil fields of West Siberia. Simferopol and Guryev moved through positions as before when the rankings were base on distance

Table 4.2

Rankings by Relative Energy Potential Based on Distance Modified by Transport Costs

OBS[a]	NODE	REP60[b]	OBS[a]	NODE	REP70[b]	OBS[a]	NODE	REP75[b]
1	KUYBYSHEV	100	1	KUYBYSHEV	100	1	KUYBYSHEV	100
2	KAZAN	75	2	KAZAN	82	2	KAZAN	82
3	UFA	72	3	UFA	74	3	UFA	76
4	ULYANOVSK	66	4	ULYANOVSK	68	4	PERM	73
5	VOROSHILOVGRAD	63	5	PERM	66	5	ULYANOVSK	68
6	SARATOV	57	6	VOROSHILOVGRAD	55	6	IZHEVSK	59
7	DONETSK	57	7	SARATOV	54	7	CHEBOKSARY	56
8	BAKU	53	8	CHEBOKSARY	54	8	SARATOV	55
9	PERM	52	9	IZHEVSK	54	9	YOSHKAR_OLA	55
10	CHEBOKSARY	51	10	YOSHKAR_OLA	53	10	VOROSHILOVGRAD	53
11	ROSTOV	50	11	DONETSK	52	11	ORENBURG	53
12	YOSHKAR_OLA	48	12	GROZNYY	51	12	DONETSK	51
13	IZHEVSK	47	13	ROSTOV	48	13	POLTAVA	49
14	PENZA	44	14	ORDZHONIKIDZE	48	14	PENZA	47
15	ORENBURG	43	15	POLTAVA	48	15	KHARKOV	47
16	KRASNODAR	42	16	PENZA	46	16	SARANSK	45
17	SARANSK	41	17	KHARKOV	46	17	CHELYABINSK	45
18	VOLGOGRAD	39	18	BAKU	45	18	GORKIY	44
19	GORKIY	38	19	ORENBURG	45	19	SVERDLOVSK	44
20	KHARKOV	37	20	SARANSK	42	20	ROSTOV	43
21	GROZNYY	36	21	GORKIY	41	21	BAKU	41
22	CHELYABINSK	35	22	SUMY	40	22	GROZNYY	40
23	TAMBOV	34	23	KRASNODAR	39	23	SUMY	40
24	STAVROPOL	34	24	VOLGOGRAD	39	24	VOLGOGRAD	40
25	ORDZHONIKIDZE	34	25	CHELYABINSK	39	25	BELGOROD	40
26	URALSK	34	26	BELGOROD	39	26	KURGAN	39
27	TULA	33	27	MAKHACHKALA	38	27	ORDZHONIKIDZE	38
28	DNEPROPETROVSK	33	28	NALCHIK	38	28	TAMBOV	38
29	VLADIMIR	32	29	TAMBOV	37	29	AKTYUBINSK	38
30	RYAZAN	32	30	DNEPROPETROVSK	37	30	TYUMEN	38
31	VORONEZH	32	31	VLADIMIR	36	31	DNEPROPETROVSK	37
32	MOSCOW	31	32	VORONEZH	36	32	VLADIMIR	37
33	KALUGA	31	33	STAVROPOL	35	33	VORONEZH	37
34	BELGOROD	31	34	LIPETSK	35	34	URALSK	37
35	LIPETSK	31	35	SVERDLOVSK	35	35	CHERNIGOV	37
36	MAKHACHKALA	31	36	URALSK	34	36	KUSTANAY	37
37	ASTRAKHAN	30	37	TULA	34	37	KEMEROVO	37
38	NALCHIK	30	38	RYAZAN	34	38	KRASNODAR	36
39	ZAPOROZHYE	30	39	ZAPOROZHYE	34	39	LIPETSK	36
40	KEMEROVO	30	40	KURSK	34	40	RYAZAN	36
41	IVANOVO	29	41	AKTYUBINSK	34	41	TULA	35
42	KURSK	29	42	MOSCOW	33	42	KURSK	35
43	POLTAVA	29	43	ASTRAKHAN	33	43	MOSCOW	35
44	SVERDLOVSK	29	44	IVANOVO	33	44	IVANOVO	35
45	AKTYUBINSK	29	45	CHERNIGOV	33	45	KIROV	35
46	OREL	28	46	KALUGA	32	46	GURYEV	35
47	BRYANSK	28	47	OREL	32	47	ZAPOROZHYE	34
48	KURGAN	28	48	CHERKASSY	32	48	KALUGA	34
49	KUSTANAY	28	49	KIEV	32	49	OREL	34
50	KIROV	7	50	BRYANSK	31	50	TOMSK	34
51	YAROSLAVL	26	51	KURGAN	31	51	NALCHIK	33
52	KALININ	26	52	KUSTANAY	31	52	STAVROPOL	33
53	KOSTROMA	26	53	KIROV	31	53	ASTRAKHAN	33
54	SUMY	26	54	YAROSLAVL	31	54	CHERKASSY	33
55	CHERKASSY	25	55	GURYEV	31	55	KIEV	33
56	LVOV	24	56	KOSTROMA	30	56	BRYANSK	33

Table 4.2--Continued

OBS	NODE	REP60	OBS	NODE	REP70	OBS	NODE	REP75
57	PETROPAVLOVSK	24	57	GOMEL	30	57	YAROSLAVL	33
58	VOLOGDA	23	58	KALININ	29	58	KOSTROMA	33
59	KIEV	23	59	TYUMEN	28	59	GOMEL	33
60	SMOLENSK	23	60	VOLOGDA	27	60	MAKHACHKALA	32
61	TBILISI	23	61	SMOLENSK	27	61	PETROPAVLOVSK	32
62	CHERNIGOV	23	62	NIKOLAYEV	27	62	KALININ	31
63	KIROVOGRAD	23	63	KHERSON	27	63	VOLOGDA	30
64	NIKOLAYEV	23	64	KEMEROVO	26	64	SMOLENSK	30
65	KHERSON	23	65	PETROPAVLOVSK	26	65	MOGILEV	30
66	TYUMEN	23	66	ZHITOMIR	26	66	OMSK	30
67	KARAGANDA	23	67	LVOV	25	67	NOVOSIBIRSK	30
68	ELISTA	23	68	MOGILEV	25	68	KOKCHETAV	29
69	ZHITOMIR	22	69	TBILISI	24	69	NIKOLAYEV	28
70	SIMFEROPOL	22	70	KIROVOGRAD	24	70	KHERSON	28
71	MOGILEV	22	71	MINSK	24	71	VITEBSK	28
72	GOMEL	22	72	VINNITSA	24	72	ZHITOMIR	27
73	GURYEV	22	73	IVANO_FRANKOVSK	24	73	MINSK	27
74	VITEBSK	21	74	KHMELNITSKIY	24	74	VINNITSA	26
75	OMSK	21	75	ELISTA	23	75	KARAGANDA	26
76	KOKCHETAV	21	76	VITEBSK	23	76	SYKTYVKAR	26
77	TSELINOGRAD	21	77	KOKCHETAV	23	77	TSELINOGRAD	26
78	NOVGOROD	20	78	NOVGOROD	23	78	PAVLODAR	26
79	MINSK	20	79	TERNOPOL	23	79	LVOV	25
80	TERNOPOL	20	80	ROVNO	23	80	KIROVOGRAD	25
81	VINNITSA	20	81	ODESSA	23	81	NOVGOROD	25
82	LENINGRAD	19	82	KARAGANDA	22	82	TBILISI	24
83	PSKOV	19	83	SIMFEROPOL	22	83	KHMELNITSKIY	24
84	ROVNO	19	84	OMSK	22	84	TERNOPOL	24
85	IVANO_FRANKOVSK	19	85	BREST	22	85	ROVNO	24
86	KHMELNITSKIY	19	86	LUTSK	22	86	ODESSA	24
87	ODESSA	19	87	UZHGOROD	22	87	LENINGRAD	24
88	BREST	19	88	SYKTYVKAR	22	88	BARNAUL	24
89	NOVOSIBIRSK	19	89	TSELINOGRAD	21	89	IVANO_FRANKOVSK	23
90	VILNIUS	18	90	LENINGRAD	21	90	ELISTA	23
91	YEREVAN	18	91	VILNIUS	21	91	BREST	23
92	LUTSK	18	92	CHERNOVSTY	21	92	LUTSK	23
93	UZHGOROD	18	93	PSKOV	20	93	VILNIUS	23
94	CHERNOVSTY	18	94	YEREVAN	20	94	KRASNOYARSK	23
95	TOMSK	18	95	KISHINEV	20	95	SIMFEROPOL	22
96	KZYL_ORDA	18	96	GRODNO	20	96	UZHGOROD	22
97	PETROZAVODSK	17	97	NOVOSIBIRSK	19	97	CHERNOVSTY	22
98	ARKHANGELSK	17	98	RIGA	19	98	PSKOV	22
99	SYKTYVKAR	17	99	PAVLODAR	19	99	RIGA	22
100	KISHINEV	17	100	TALLIN	19	100	ASHKHABAD	22
101	RIGA	17	101	TOMSK	18	101	KISHINEV	21
102	BARNAUL	17	102	KZYL_ORDA	18	102	GRODNO	21
103	PAVLODAR	17	103	PETROZAVODSK	18	103	TALLIN	21
104	ASHKHABAD	17	104	ARKHANGELSK	18	104	KZYL_ORDA	21
105	TALLIN	16	105	ASHKHABAD	18	105	CHIMKENT	21
106	KALININGRAD	16	106	TASHKENT	18	106	YEREVAN	20
107	GRODNO	16	107	CHIMKENT	17	107	PETROZAVODSK	20
108	CHIMKENT	15	108	BARNAUL	16	108	ARKHANGELSK	20
109	TASHKENT	15	109	KALININGRAD	16	109	TASHKENT	20
110	KRASNOYARSK	14	110	DZHAMBUL	16	110	ABAKAN	20
111	ABAKAN	14	111	KRASNOYARSK	15	111	DZHAMBUL	19
112	DZHAMBUL	14	112	FRUNZE	15	112	KALININGRAD	18

Table 4.2--Continued

OBS	NODE	RFP60	OBS	NODE	RFP70	OBS	NODE	RFP75
113	SEMIPALATINSK	14	113	ABAKAN	14	113	FRUNZE	19
114	UST_KAMENOGORSK	14	114	SEMIPALATINSK	14	114	SEMIPALATINSK	18
115	FRUNZE	14	115	UST_KAMENOGORSK	14	115	UST_KAMENOGORSK	17
116	MURMANSK	12	116	ALMA_ATA	14	116	ALMA_ATA	17
117	IRKUTSK	12	117	MURMANSK	13	117	DUSHANBE	16
118	ALMA_ATA	12	118	DUSHANBE	12	118	MURMANSK	15
119	DUSHANBE	11	119	IRKUTSK	11	119	IRKUTSK	15
120	CHITA	8	120	ULAN_UDE	9	120	ULAN_UDE	12
121	ULAN_UDE	8	121	CHITA	8	121	CHITA	11
122	VLADIVOSTOK	6	122	VLADIVOSTOK	6	122	BLAGOVESHCHENSK	8
123	KHABAROVSK	6	123	KHABAROVSK	6	123	VLADIVOSTOK	7
124	BLAGOVESHCHENSK	6	124	BLAGOVESHCHENSK	6	124	KHABAROVSK	7
125	YAKUTSK	6	125	YAKUTSK	6	125	YAKUTSK	7
126	MAGADAN	5	126	MAGADAN	5	126	MAGADAN	6
127	YUZHNO_SAKHALINSK	4	127	YUZHNO_SAKHALINSK	5	127	YUZHNO_SAKHALINSK	6
128	PETROPAVLOVSK_KAM	4	128	PETROPAVLOVSK_KAM	5	128	PETROPAVLOVSK_KAM	6
129	NORILSK	1	129	NORILSK	0	129	NORILSK	0

[a] Approximate rankings by rounded relative energy potentials. Rankings mentioned in text are by unrounded absolute energy potential indices.

[b] Relative energy potential for 1960, 1970, and 1975 as percentage of Kuybyshev.

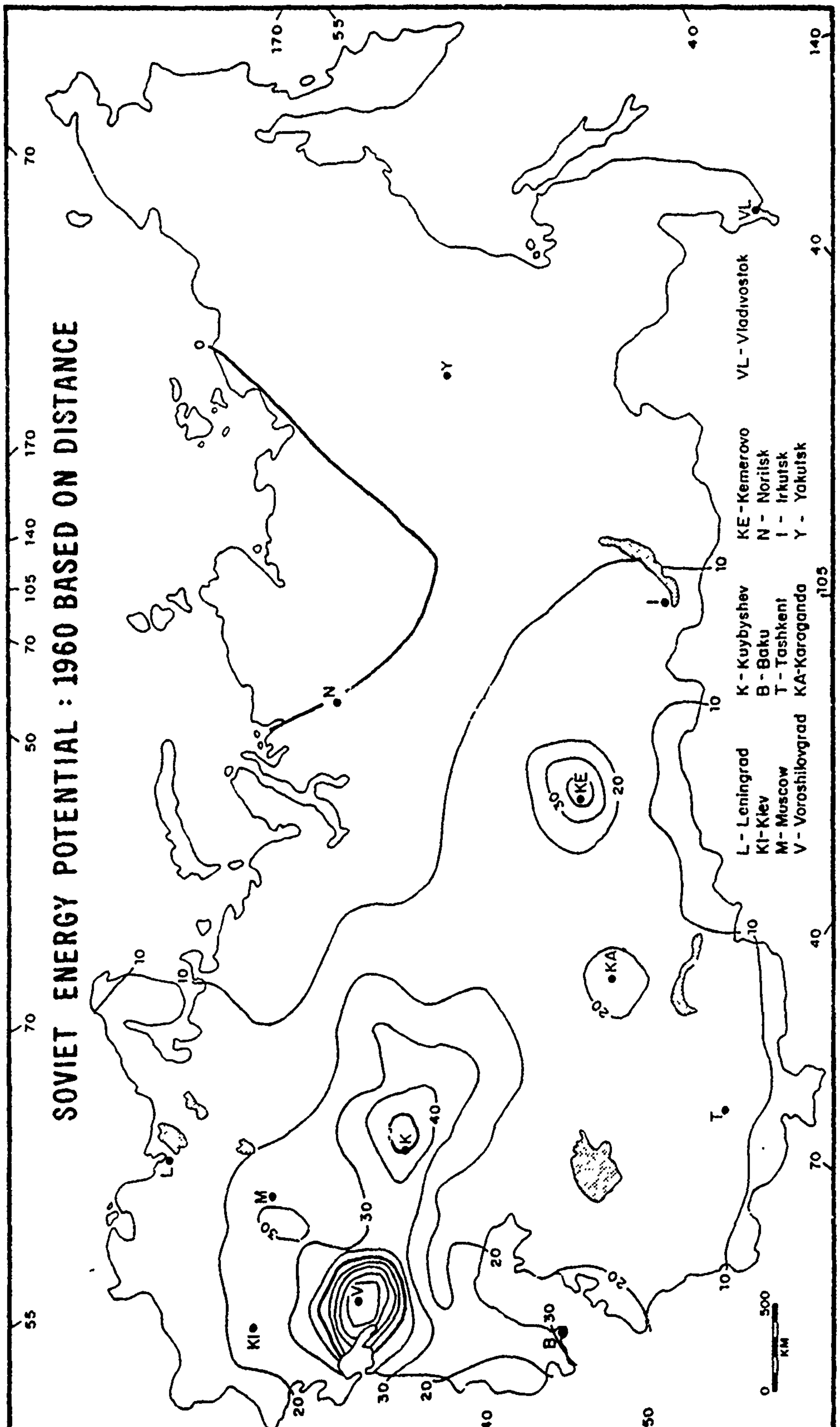
alone, but their changes in rankings were not quite as large. The areas with the lowest energy potential based on transport costs during 1960-1975 were generally the same as those when energy accessibility was determined by distance. The overall patterns of energy accessibility based on transport costs varied even less through time than those for distance, with correlation coefficients of +0.97 for 1960 and 1970, +0.97 for 1970 and 1975, and +0.95 for 1960 and 1975.

The patterns of energy accessibility using unmodified distance are similar to those determined by distance modified by transport costs. The correlations between the two sets of values were high with correlation coefficients of +0.78 for 1960, +0.83 for 1970, and +0.84 for 1975. This similarity occurs because, although the top positions changed from one set of rankings to the other, the bulk of the nodes remained fairly constant in their positions. Moscow, for example, fluctuated between 32nd and 43rd places when the rankings were based on distance and between 34th and 44th places when transport costs were used. Moscow's values were somewhat higher than might otherwise have been expected because of its distance from major sources of energy, but Moscow benefits from being the center of the transportation network in the European USSR. Energy thus has a shorter distance to travel to get to Moscow than to other nodes around Moscow.

The energy potential indices of the 129 nodes were used to construct maps showing energy accessibility as calculated using distance and distance modified by transport costs for 1960, 1970, and 1975 (Figures 4.1 through 4.6). On the basis of the indices determined for each node, contour lines of equal energy potential were drawn. For easier comparison, the values of the contour lines are expressed as percentages

FIGURE 4.1

Source: Data for outline and cities taken from Soviet Union, National Geographic Society, 1976, transverse polyconic projection.



SOVIET ENERGY POTENTIAL : 1960 BASED ON DISTANCE

FIGURE 4.2

Source: Data for outline and cities taken from *Soviet Union*, National Geographic Society, 1976, transverse polyconic projection.

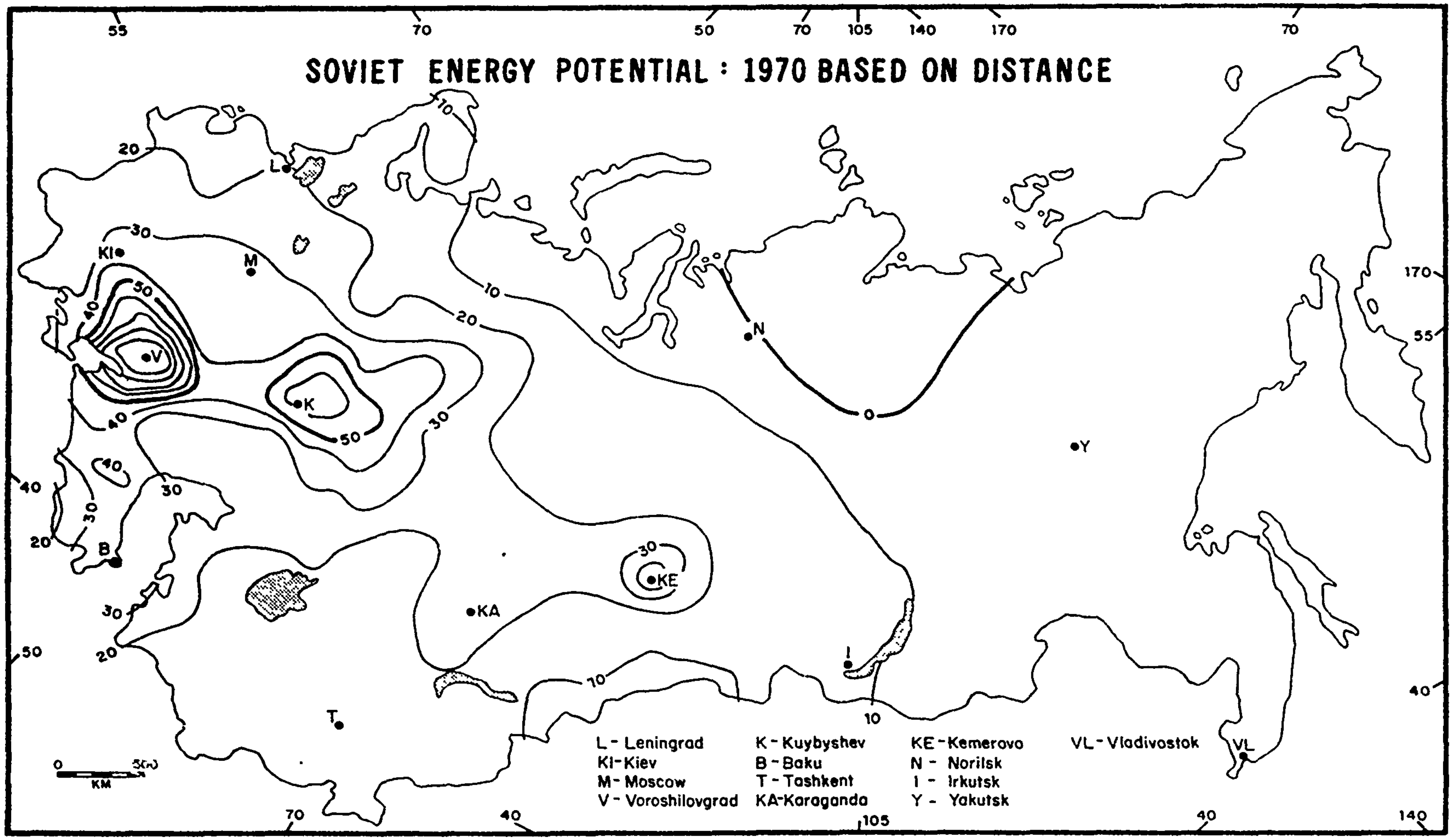
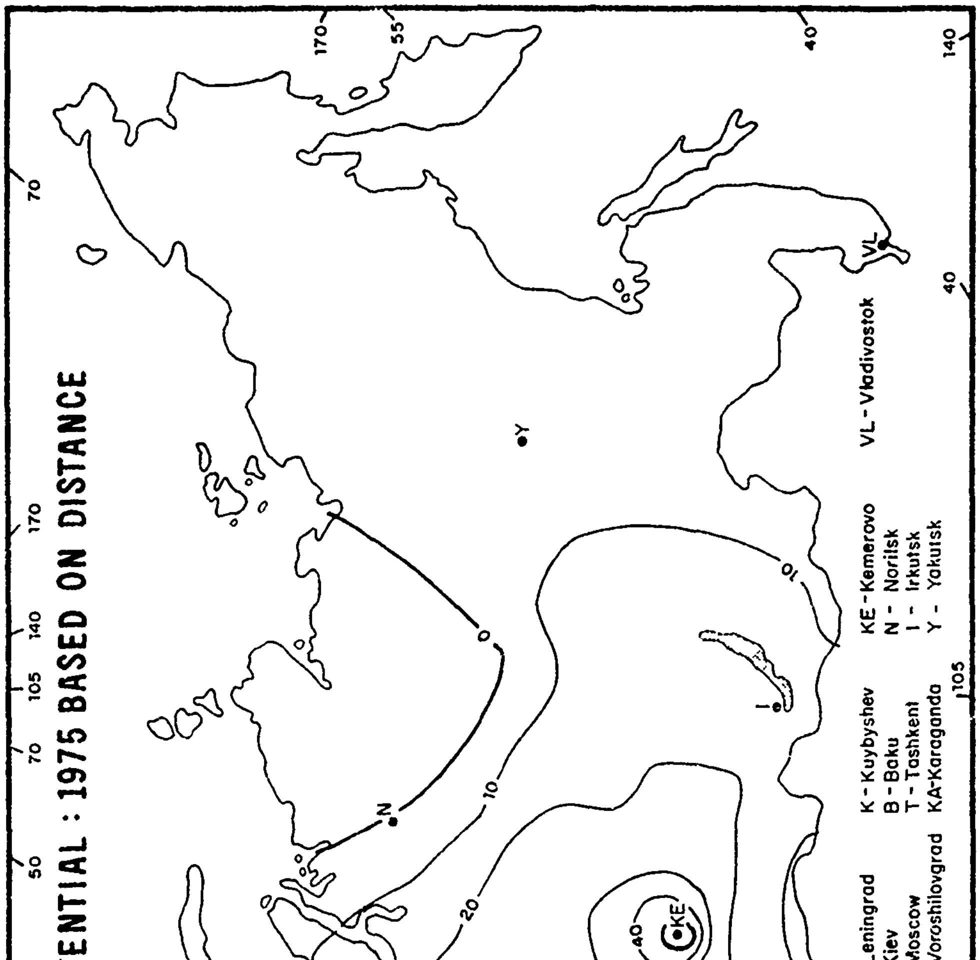

SOVIET ENERGY POTENTIAL : 1970 BASED ON DISTANCE
L - Leningrad
KI - Kiev
M - Moscow
V - Voroshilovgrad
K - Kuybyshev
B - Baku
T - Tashkent
KA - Karaganda
KE - Kemerovo
N - Norilsk
I - Irkutsk
Y - Yakutsk
VL - Vladivostok
KM

FIGURE 4.3

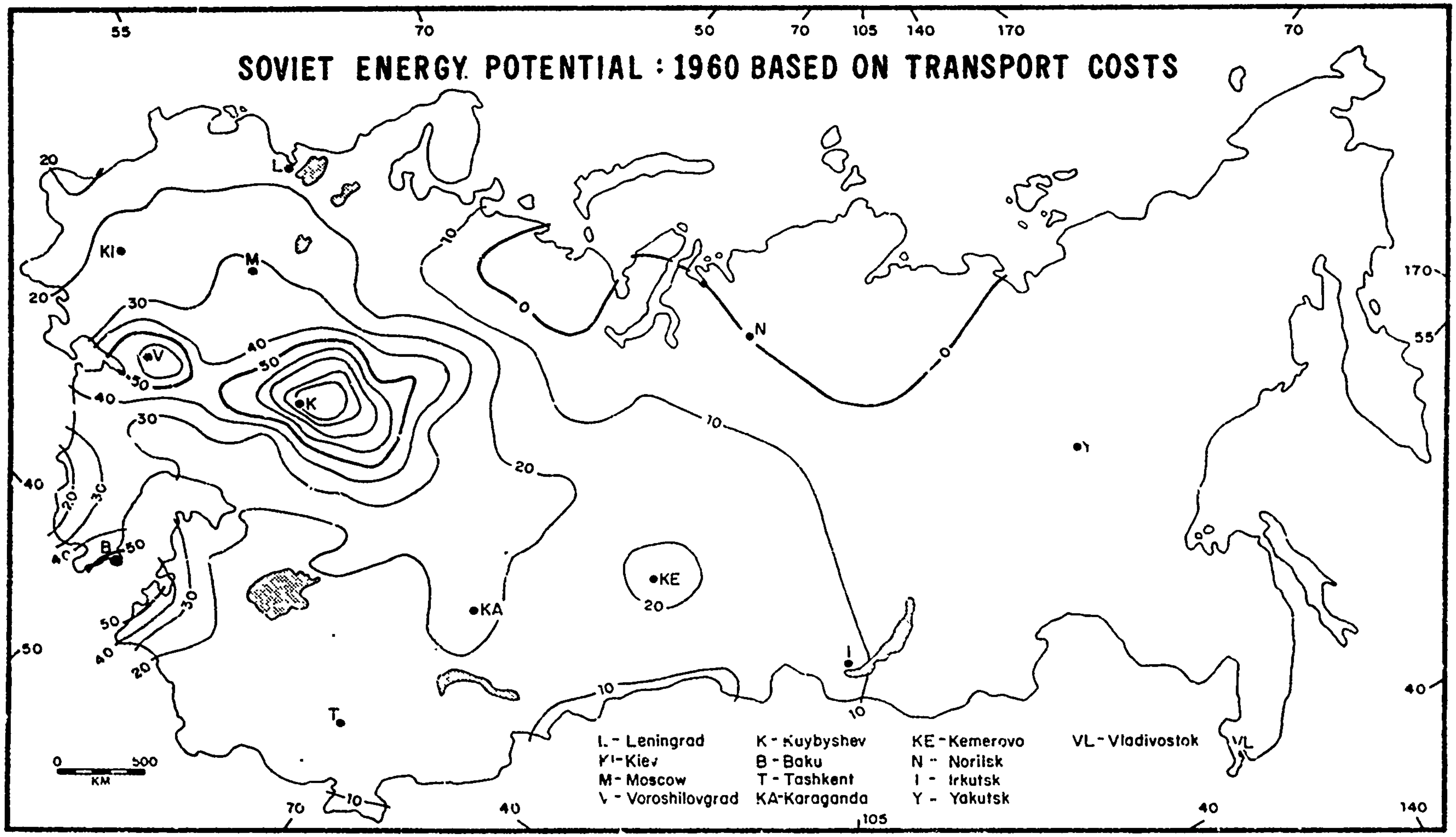
Source: Data for outline and cities taken from <u>Soviet Union</u>, National Geographic Society, 1976 transverse polyconic projection.



SOVIET ENERGY POTENTIAL : 1975 BASED ON DISTANCE

FIGURE 4.4

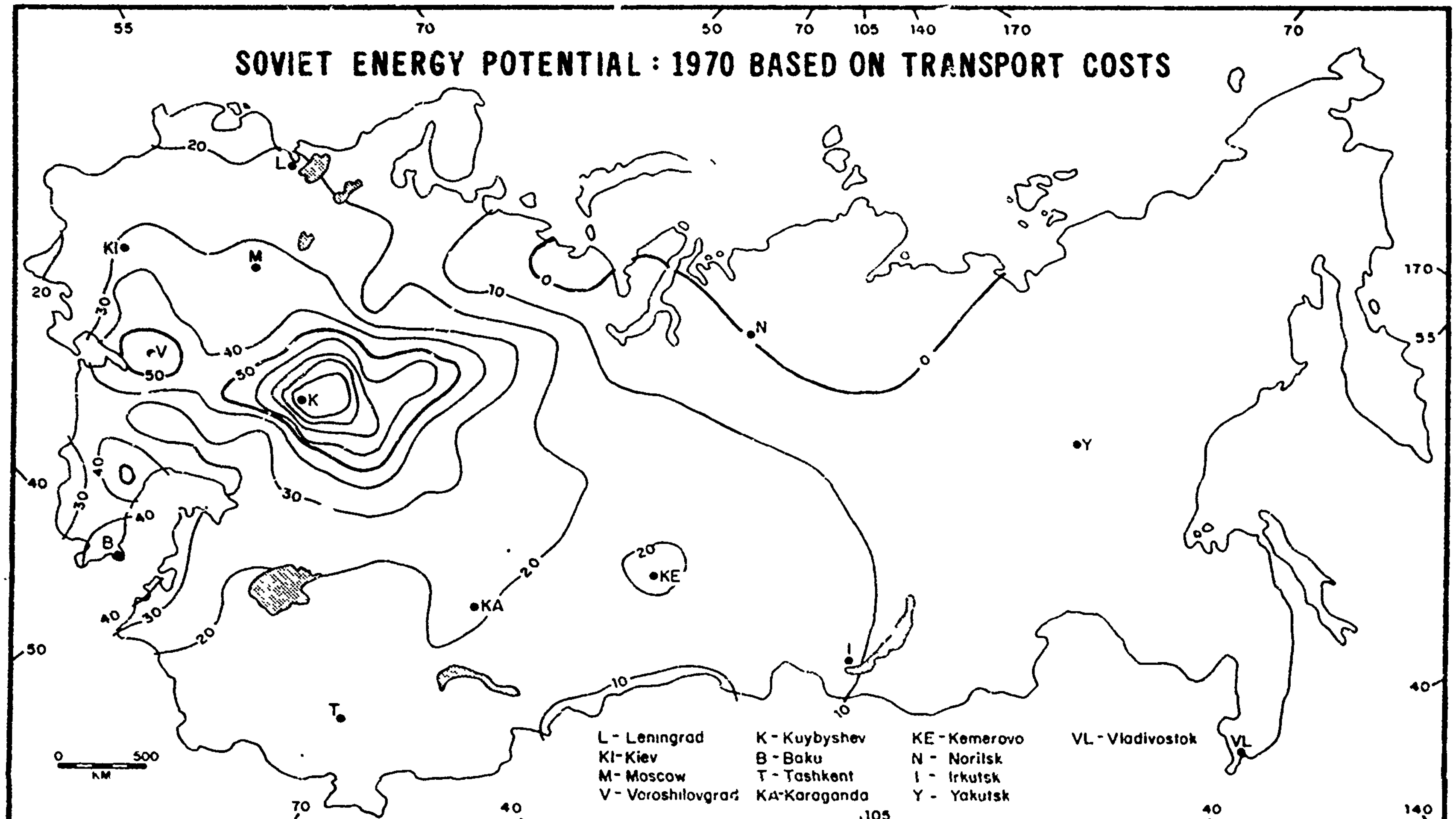
Source: Data for outline and cities taken from Soviet Union, National Geographic Society, 1976, transverse polyconic projection.



SOVIET ENERGY POTENTIAL : 1960 BASED ON TRANSPORT COSTS

FIGURE 4.5

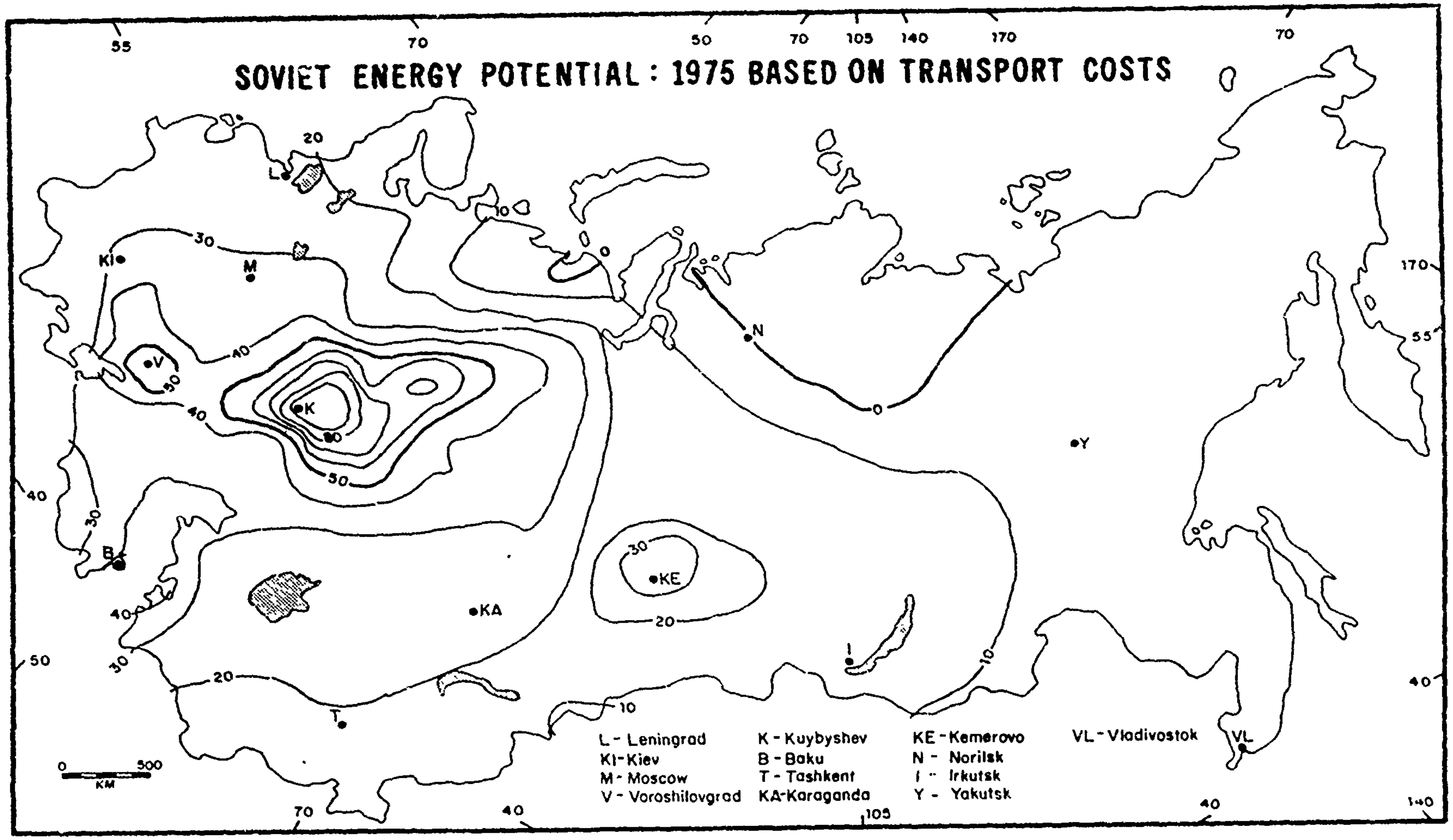
Source: Data for outline and cities taken from <u>Soviet Union</u>, National Geographic Society, 1976, transverse polyconic projection.



SOVIET ENERGY POTENTIAL : 1970 BASED ON TRANSPORT COSTS

FIGURE 4.6

Source: Data for outline and cities taken from <u>Soviet Union</u>, National Geographic Society, 1976, transverse polyconic projection.


SOVIET ENERGY POTENTIAL : 1975 BASED ON TRANSPORT COSTS
L - Leningrad
KI - Kiev
M - Moscow
V - Voroshilovgrad
K - Kuybyshev
B - Baku
T - Tashkent
KA - Karaganda
KE - Kemerovo
N - Norilsk
I - Irkutsk
Y - Yakutsk
VL - Vladivostok
0 500 KM
0
10
20
30
40
50
55
70
105
140
170

of the nodes having the highest energy potential. The contour interval is ten percentage, and the zero and 50 percentage lines are darker than the other lines. These nodes are Voroshilovgrad for the maps based on distance and Kuybyshev for the maps based on transport costs.

The 1960 energy potential map based on distance alone (Figure 4.1) contained two major peaks and one minor peak. The dominant peak occurs in the eastern Ukraine and North Caucasus area where Voroshilovgrad, Donetsk, and Rostov are so favorably located in the Donets Basin. This peak subsumes a large part of the Donets-Dnepr industrial complex. A secondary major peak rises over the Volga-Urals oil fields and straddles the boundary between the Volga and the Urals industrial regions. A minor peak is centered over Kemerovo and the Kuznetsk Basin and is coincident with the Kuzbas heavy industrial region. There is a slight rise around Baku, and closed contour lines surround the Moscow and Karaganda coal basins. Despite the region's huge energy reserves, the nodes in the trans-Baikal area have the lowest relative energy accessibility values in the U.S.S.R. because of their great distance from major energy producing sources.

The Donets Basin peak also dominates the 1970 energy potential map based on distance (Figure 4.2), but the Volga-Urals peak increases its relative height and area because of the doubling of oil production in that region between 1960 and 1970. A slight spur now runs from Voroshilovgrad westward to Kharkov and Poltava because of the five-fold increase in production of the east Ukrainian natural gas fields and the discovery of oil near Poltava. A notable prolongation extends eastward from Kuybyshev through Ufa generally along the Trans-Siberian Railroad to Kemerovo and encompasses Karaganda. A minor peak appears in the

North Caucasus region around Groznyy and Ordzhonikidze because of a dramatic but temporary spurt in pro ction of the Chechen-Ingush ASSR oil fields.

The size and shape of the Voroshilovgrad energy potential peak remained virtually unchanged in 1975 (Figure 4.3), while the Volga-Urals peak grew in height and expanded its base northward and eastward to include the cities of the eastern Urals region. This expansion was influenced by production from the middle-Ob oil fields of Tyumen Oblast. Increased coal production at the Kuznetsk Basin aided by input from the middle-Ob oil fields, enabled the Kemerovo peak to grow and expand with a prolongation southwestward to include Karaganda.

The Volga-Urals oil fields peak towers over the map of relative energy potential based on distance modified by transport costs in 1960 (Figure 4.4). Two secondary peaks are centered over the Donets Basin and the Baku oil fields. A closed contour line surrounds Kemerovo because of the Kuznetsk Basin. The peaks at Voroshilovgrad and Kuybyshev bulge toward each other as though they might coalesce, but this never happens because the production of the Donets Basin rose only slightly from 1960 while the Volga-Urals production doubled from 1960 to 1970.

The patterns vary little from 1960 to 1970 (Figure 4.5). The peak at Voroshilovgrad has shrunk a bit, but a slight prolongation now runs northwestward through the gas and oil fields near Kharkov and Poltava. The peak at Kuybyshev has expanded its base, and the distended ridge running northeast to Perm is more pronounced. The spasmodic increase in production of the Groznyy oil fields is evident in the minor peak appearing in the eastern North Caucasus region.

The Groznyy peak disappears by 1975 (Figure 4.6), and the peak at Voroshilovgrad has diminished even more. The base of the Volga-Urals peak expands eastward and northward as the cities of the eastern Urals region increase their energy potentials because of the influence of the West Siberian oil fields along the Ob. There is a small rise in the Kuznetsk Basin area, but the values there are generally less than those in the Central region around Moscow.

A few general observations can be made about both series of energy potential maps. The areas with the lowest energy accessibility were the Far East, East Siberia, the Northwest, Soviet Central Asia, the Baltic states, and the area along the western border of the country. The latter three areas contain some of the highest concentrations of population in the Soviet Union and some of the nodes with the highest urban population growth rates as well as the Leningrad industrial region. On all maps, major peaks occur in or near the Donets-Dnepr, Volga, and Urals industrial areas, and minor peaks often rise at the Baku, Karaganda, and Kuznetsk industrial centers. The nodes of the long-established industrialized region around Moscow displayed moderate energy potential values largely because of their locations with respect to the Donets Basin and Volga-Urals oil fields. The dramatic increases in the oil and natural gas production of West Siberia were reflected by modest eastward and northward shifts in the base of the Volga-Urals peak.

Urban Population Growth and Energy Accessibility

The relationship between urban population growth and energy accessibility was analyzed using urban population data from the 1959, 1970, and 1979 censuses (Appendix E) and nodal energy potential indices for 1960,

1970, and 1975 based on distance and transport costs. Norilsk and Elista were not included in the correlation analyses because Norilsk had been treated as a separate system with no energy inputs from sources other than those in its immediate area and because population data for Elista were not available for the entire period of study.

The results of the correlation analysis between the urban population data and energy accessibility based on distance revealed that energy accessibility has had little impact on urban population growth (Table 4.3). Those nodes with high growth rates were, in fact, located away from areas of high energy accessibility as indicated by the negative signs of the correlation coefficients between urban population growth and energy potential. A small positive relationship exists, however, between changes in energy accessibility and urban population growth. Evidence of a lag effect is present in that the change in energy accessibility 1960-1970 had a higher correlation with urban population growth 1970-1979 than did the change in energy accessibility 1960-1970 with urban population growth 1959-1970. The evidence of a lag effect is also supported by the lack of any significant correlation between urban population growth 1970-1979 and the change in energy accessibility 1970-1975. As might be expected, the correlation coefficients between urban population and urban population growth demonstrates that larger cities tend to grow at slower rates than small cities. The substantial correlation between urban population growth 1959-1970 and urban population growth 1970-1979 shows that the patterns of growth were somewhat similar during both periods.

The correlation coefficients matrix for urban population data and energy accessibility calculated using transport costs again indicates

Table 4.3

CORRELATION COEFFICIENTS AND SIGNIFICANCE LEVELS BETWEEN URBAN POPULATION DATA AND ENERGY ACCESSIBILITY BASED ON DISTANCE

	POP59[a]	POP70[a]	GROWTH1[b]	GROWTH2[c]	TEP60[d]	TEP70[d]	TEP75	CHANGE1[e]	CHANGE2[f]	CHANGE3[g]
POP59	1.00000	0.99692	-0.35560	-0.32300	0.14326	0.13375	0.1413[illegible]	.05780	-0.04865	-0.09165[h]
	0.0000	0.0001	0.0001	0.0002	0.1081	0.1338	0.1130	0.5136	0.5870	0.3615[i]
POP70	0.99692	1.00000	-0.34005	-0.33949	0.14902	0.14130	0.15103	-0.05194	-0.04119	-0.04908
	0.0001	0.0000	0.0001	0.0001	0.0945	0.1131	0.0901	0.5520	0.6457	0.4403
GROWTH1	-0.35560	-0.34005	1.00000	0.69994	-0.17415	-0.12489	-0.11625	0.21716	0.08035	0.27070
	0.0001	0.0001	0.0000	0.0001	0.0502	0.1618	0.1931	0.0142	0.3692	0.0021
GROWTH2	-0.32300	-0.33949	0.69994	1.00000	-0.22160	-0.16656	-0.17260	0.25768	-0.00007	0.23350
	0.0002	0.0001	0.0001	0.0000	0.0123	0.0613	0.0523	0.0034	0.9994	0.0082
TEP60	0.14326	0.14902	-0.17415	-0.22160	1.00000	0.95587	0.93687	-0.06927	-0.38515	-0.34330
	0.1081	0.0945	0.0502	0.0123	0.0000	0.0001	0.0001	0.4390	0.0001	0.0001
TEP70	0.13375	0.14130	-0.12489	-0.16656	0.95587	1.00000	0.97949	0.19263	-0.46688	-0.16452
	0.1338	0.1131	0.1618	0.0613	0.0001	0.0000	0.0001	0.0300	0.0001	0.0613
TEP75	0.14134	0.15103	-0.11625	-0.17260	0.93687	0.97949	1.00000	0.16908	-0.30368	-0.05987
	0.1130	0.0901	0.1931	0.0523	0.0001	0.0001	0.0000	0.0574	0.0005	0.5037
CHANGE1	-0.05780	-0.05194	0.21716	0.25768	-0.06927	0.19263	0.16908	1.00000	-0.32280	0.67961
	0.5136	0.5520	0.0142	0.0034	0.4390	0.0300	0.0574	0.0000	0.0002	0.0001
CHANGE2	-0.04865	-0.04119	0.08035	-0.00007	-0.38515	-0.46688	-0.30368	-0.32280	1.00000	0.46822
	0.5870	0.6457	0.3692	0.9994	0.0001	0.0001	0.0005	0.0002	0.0000	0.0001
CHANGE3	-0.09165	-0.04908	0.27070	0.23350	-0.34330	-0.16452	-0.05987	0.67961	0.46822	1.00000
	0.3615	0.4403	0.0021	0.0082	0.0001	0.0613	0.5037	0.0001	0.0001	0.0000

[a]Population 1959 and 1970

[b]Urban population growth 1959-1970

[c]Urban population growth 1970-1979

[d]Total energy potential 1960, 1970, and 1975

[e]Change in energy potential 1960-1970

[f]Change in energy potential 1970-1975

[g]Change in energy potential 1970-1975

[h]Correlation coefficients

[i]Significance levels

Table 6.4

CORRELATION COEFFICIENTS AND SIGNIFICANCE LEVELS BETWEEN URBAN POPULATION DATA AND ENERGY ACCESSIBILITY BASED ON TRANSPORT COSTS

	POP59[a]	POP70[a]	GROWTH1[b]	GROWTH2[c]	TEP60[d]	TEP70[d]	TEP75[d]	CHANGE1[e]	CHANGE2[f]	CHANGE3[g]	
POP59	1.00000	0.99692	-0.35560	-0.32800	0.15116	0.12710	0.13497	-0.10613	-0.03770	-0.11038	h
	0.0000	0.0001	0.0001	0.0002	0.0895	0.1544	0.1303	0.2350	0.6739	0.2167	i
POP70	0.99692	1.00000	-0.34005	-0.33049	0.15968	0.13571	0.14503	-0.10379	-0.03496	-0.10496	
	0.0001	0.0000	0.0001	0.0001	0.0729	0.1292	0.1038	0.2455	0.6964	0.2402	
GROWTH1	-0.35563	-0.34005	1.00000	0.69994	-0.15007	-0.09836	-0.09326	0.26767	0.00667	0.22470	
	0.0001	0.0001	0.0000	0.0001	0.0922	0.2713	0.2970	0.0023	0.9406	0.0111	
GROWTH2	-0.32800	-0.33049	0.69994	1.00000	-0.24947	-0.19473	-0.20144	0.32617	-0.02791	0.23394	
	0.0002	0.0001	0.0001	0.0000	0.0047	0.0282	0.0231	0.0002	0.7554	0.0081	
TEP60	0.15116	0.15968	-0.15007	-0.24947	1.00000	0.96941	0.95160	-0.13867	-0.44741	-0.50756	
	0.0898	0.0729	0.0922	0.0047	0.0000	0.0001	0.0001	0.1200	0.0001	0.0001	
TEP70	0.12710	0.13571	-0.09836	-0.19473	0.96941	1.00000	0.97410	0.08845	-0.50827	-0.39826	
	0.1544	0.1292	0.2713	0.0282	0.0001	0.0000	0.0001	0.3229	0.0001	0.0001	
TEP75	0.13497	0.14503	-0.09326	-0.20144	0.95160	0.97410	1.00000	0.04827	-0.32835	-0.25729	
	0.1303	0.1038	0.2970	0.0231	0.0001	0.0001	0.0000	0.5900	0.0002	0.0035	
CHANGE1	-0.10613	-0.10379	0.26767	0.32617	-0.13867	0.08845	0.04827	1.00000	-0.29827	0.47481	
	0.2350	0.2455	0.0023	0.0002	0.1200	0.3228	0.5900	0.0000	0.0007	0.0001	
CHANGE2	-0.03770	-0.03496	0.00667	-0.02791	-0.44741	-0.50827	-0.32835	-0.29927	1.00000	0.69211	
	0.6739	0.6964	0.9406	0.7554	0.0001	0.0001	0.0002	0.0007	0.0000	0.0001	
CHANGE3	-0.11038	-0.10496	0.22470	0.23394	-0.50756	-0.39826	-0.25729	0.47481	0.69211	1.00000	
	0.2167	0.2402	0.0111	0.0081	0.0001	0.0001	0.0035	0.0001	0.0001	0.0000	

[a]Population 1959 and 1970

[b]Urban population growth 1959-1970

[c]Urban population growth 1970-1979

[d]Total energy potential 1960, 1970, and 1975

[e]Change in energy potential 1960-1970

[f]Change in energy potential 1970-1975

[g]Change in energy potential 1960-1975

[h]Correlation coefficients

[i]Significance levels.

that those nodes with high growth rates tended to have low energy potential (Table 4.4). Changes in energy accessibility based on transport costs have a stronger relationship with urban population growth than did energy accessibility based on distance. The stronger relationship of energy accessibility based on transport costs with urban population growth reflects the superiority of transport costs over sheer distance as a measure of impedance. Evidence of a lag effect of changes in energy accessibility on urban population growth is even more pronounced than before. This is exhibited by the higher correlation coefficient between the change in energy accessibility 1960-1970 and urban population growth 1970-1979.

Summary

The analysis of energy accessibility revealed peaks and troughs which were fairly stable through time and relatively invariant with regard to the way energy accessibility was calculated. Nodes in two areas, the Donets Basin and the Volga-Urals oil fields, had the highest energy potential indices. Voroshilovgrad in the eastern Ukraine was ranked first when energy accessibility was determined by distance alone, and Kuybyshev was first when transport costs were used. East Siberia, the Far East, the Northwest, the Baltic states, Belorussia, the western Ukraine, Moldavia, and Soviet Central Asia had the lowest accessibility to energy based on actual energy production. Areas with moderate levels of energy accessibility were the Kuznetsk Basin, the North Caucasus, and Baku. Moscow and the Central industrial region had modest levels of energy accessibility. The energy potential patterns as determined by distance were fairly similar to those determined by transport costs. These

patterns also changed little between 1960 and 1975 despite the eastward shift in emphasis of energy production. The huge oil and gas fields of Western Siberia were simply too far away from any of the nodes studied to have more than a modest impact on energy potential patterns, although there was a gradual eastward expansion of the base of the Volga-Urals peak between 1960 and 1975.

Three major industrial regions of the Soviet Union, the Donets-Dnepr, Volga, and Urals, are nearly coincident with the areas of highest energy accessibility. The Central, Karaganda, Baku, and Kuznetsk Basin industrial areas had energy accessibility values ranging from moderate to moderately high respectively. Leningrad and the emerging industrial area around Tashkent had low energy potential values. Some of the areas with the lowest energy potentials were also those with high urban population growth rates, such as Soviet Central Asia, Belorussia, Lithuania, and Moldavia. This high urban population growth was generally due to high birth rates and rural to urban migration potential. On the other hand, many nodes in the well-established, industrial regions which have high energy accessibility values displayed relatively low growth rates. These low growth rates were the result of an already high level of urbanization, low rates of natural increases in population, and lack of rural to urban migration potential.

The correlation analysis between urban population growth and energy accessibility supported the apparent disconformity between patterns of high urban population growth and high energy accessibility. Changes in energy accessibility were, however, positively correlated with urban population growth. A lag effect was evident in the correlation between

the change in energy accessibility 1960-1970 and urban population growth 1970-1979.

The role of energy accessibility in Soviet urban population growth appears to be relatively modest at best. Reasons for this modest role will be considered in the final chapter.

CHAPTER V

CONCLUSION

Introduction

"Coal is the actual bread of industry; without this bread, industry cannot function" (Lenin as quoted by Hodgkins 1961, p. 40). What Lenin said about coal in the early 1920s can now be applied to oil and gas as well. Energy, in whatever form, is absolutely essential for most endeavors of modern man. Because of the essential nature of energy to industry, it was intuitively appealing to strive to establish a link between energy accessibility and urban population growth, which can be regarded a fair indicator of industrial growth under the Soviet system. The purpose of this research, then, was to determine the patterns of energy accessibility in the Soviet Union, examine the spatial and temporal variations of such patterns, and investigate the influence of energy accessibility on urban population growth. This purpose was accomplished, but the study would be incomplete without a discussion of the implications of the results of this research on urban population growth, industrilocation, and regional development. Two sections follow. The first deals with implications; the second suggests areas for future research.

Implications

There have been excellent works on the growth of Soviet cities and the Soviet energy system, but this is the first in-depth study examining

the interrelationships between energy and urban population growth on a macrogeographic basis. This work is also unique in that it represents a new application of potential models to determine patterns of energy accessibility. There are several implications regarding the results of this study.

The influence of energy accessibility on urban population growth on a nation-wide level proved to be relatively modest. Although access to energy can dramatically affect the growth of individual cities or groups of cities (Bond and Lydolph 1979; Harris 1971; Lydolph et al. 1978), other factors are clearly more important in determining Soviet urban population growth. Regional variations in levels of urbanization, rural to urban migration potential, and natural increase in population result in high urban population growth for nodes with relatively low levels of energy accessibility. Lithuania, Belorussia, Moldavia, and Central Asia are examples. Rural to urban migration was a major factor in the high urban population growth in Lithuania, Belorussia, and Moldavia. Natural increase in population was less important in those three republics, although Lithuania had the highest rate among the Baltic states, Belorussia had the highest rate among the Slavic republics, and Moldavia was above the national average. Levels of urbanization were important in Moldavia and Soviet Central Asia, both of which are still predominately rural. Natural increase in population was the dominant factor in urban population growth in Central Asia which had rates of natural increase in population two to three times higher than the national average (Bond and Lydolph 1979).

Nodes in the Donets-Dnepr, Volga, Urals, and Kuzbas industrial regions all had relatively high energy potential indices, but their urban

population growth was generally well below the national average. These well-established industrial regions were characterized by high levels of urbanization, low rural to urban migration potential, and low natural increase in population. In addition, increasing mechanization of coal mining and the decreasing importance of coal in the Soviet energy budget adversely affected urban population growth of cities in coal mining regions such as the Donets, Kuznetsk, and Karaganda basins (Bond and Lydolph 1979; Harris 1971).

Energy may act as a catalyst for economic activities, and a city undoubtedly requires a certain minimum level of energy to survive or prosper. Despite the wide range in levels of energy accessibility, all cities in this study apparently had access to enough energy to sustain urban population growth. Any amount of energy over the minimum requirement may have been largely superfluous, though there was a small positive correlation between changes in energy accessibility and urban population growth.

The eastward shift in energy production and grandiose construction projects such as the Baikal Amur Mainline or BAM in Siberia and the Far East do not necessarily portend an eastward shift in urban population growth and industry. The eastward shift in energy production to sites that are far away from the market areas of the western part of the U.S.S.R. has been forced on the Soviets by the need for more energy to fuel economic growth and to earn hard currency from energy exports. The Soviets are building the BAM for several reasons: (1) to relieve the overburdened Trans-Siberian Railroad, (2) to open remote resource areas for exploitation, (3) to bolster defense capabilities in Siberia and the

Far East, and (4) to strengthen foreign and domestic commercial ties (Lydolph 1979, pp. 424-425).

The eastward shift in energy production and the completion of the Baikal Amur Mainline may stimulate some settlement in areas of Siberia and the Far East which are now largely uninhabited. Some cities in those areas may exhibit spectacular growth rates, such as Surgut near the Samotlor oil fields of Western Siberia, but these will be resource oriented "boom towns" whose growth is closely dependent on production trends. The hostile environment and labor shortage in much of Siberia and the Far East are severe constraints on regional development in those areas, and the Soviets will probably meet with only limited success with their plans to urbanize and industrialize areas such as the lower reaches of the Yenisey (Myakinenkov 1975).

The high urban population growth demonstrated by nodes with low accessibility to energy supports the notion that the Soviets have yielded to the pull of the market as a factor in industrial location as suggested by Soviet geographer A.A. Mints (1976) and American geographers, Lydolph and Pease (1972). Energy resource location will more than likely continue to be a lesser important factor in industrial location. The "fluid" nature of oil and natural gas and the rapidly expanding pipeline networks have doubly blessed the Soviets by facilitating the export of oil and natural gas to Eastern and Western Europe and by enabling the Soviets to develop the energy-poor western areas of their own country. Future emphasis will likely be on developing mineral resources, such as the Kursk Magnetic Anomaly, in the market areas of the western U.S.S.R. where there is an available labor pool (Lydolph and Pease 1972).

The findings and maps compiled as the result of this study might be useful in small-scale economic planning for the Soviets. The data points for which energy accessibility was calculated were major administrative and industrial nodes generally within the "fertile triangle" of the Soviet Union. The energy potential indices and maps thus represent or portray energy accessibility of market areas within the Soviet Union rather than areas that are sparsely inhabited. Siberia and the Far East may possess vast reserves of energy resources, but such reserves are like the coal field described by Harris (1954) as "useless until it falls within the technological capabilities of specific human groups and until it can be utilized in a favorable economic environment" (p. 315).

Contour maps of energy potential would probably be more useful to Soviet economic planners in making industrial location decisions than existing choropleth maps of resource potential (See: Mints and Kakhanovskaya 1975). Soviet geographers have long advocated the location of industry in small and medium-size cities of their country (Mikhailov and Solovev 1969). Industry could be located in such cities in or near areas of high energy accessibility such as between the Donets Basin and the Volga-Urals oil fields. This would minimize transport costs because the industry would be fairly close to energy sources as well as still within the market area of the Soviet Union. This would also achieve other aims which the Soviets have been striving for, such as a reduction in the excessive concentration of industrial production in large cities and a more equitable distribution of population and industrial production (Koropeckyj 1970; Mikhailov and Solovev 1969).

Areas for Future Research

The aims of this study were achieved, but future research might be undertaken in a number of related areas. Changes in energy accessibility based on generalized transport costs had slightly stronger correlations with urban population growth that did changes in energy accessibility based on distance alone. This suggests that transport costs are a superior measure of friction in accessibility studies than sheer distance. The same generalized transport costs were used throughout the period of study, and exponents of 1.0 were used in calculating energy potential indices. Additional research might be directed toward determining how the transport cost ratio for coal, oil, and natural gas has changed over time and what the actual exponents should be.

A temporal series of energy potential maps with energy producing sources used as data points rather than nodes in the energy consuming market area of the Soviet Union would more clearly show the dramatic eastward shift in energy production. For planning purposes, energy potential maps could be drafted based on projected production rather than on actual production. What would be the effect of including the energy imports from Poland, Afghanistan, or Iran on the patterns of energy accessibility within the Soviet Union? Conversely, should some allowance be made for the coal, oil, and natural gas that the Soviets export?

Large cities were selected for study because census data were readily available. The influence of energy accessibility on medium-size (50,000-100,000 population) should be examined. Medium-size cities might be more sensitive to changes in energy accessibility than large cities. A study utilizing medium-size cities rather than large cities

might possibly reveal more information concerning Soviet regional development priorities. Other variables, such as changes in industrial production or percentage of labor force engaged in manufacturing, could be used instead of urban population growth. Use of other variables, though, would present problems of data availability and aggregation. Urban population data were used because the Soviets are not as reticent in publishing population data as they are with economic data.

The results of this study could be included in a model for urban population growth. Additional variables could include an index of rural to urban migration potential, the rate of natural increase in population, and the population of the city. Similar energy accessibility studies could be done for other large countries of the world, such as the People's Republic of China or Brazil, which do not have homogeneous distributions of population or energy resources.

The purpose of this research was accomplished. Temporal and spatial variations in energy accessibility were determined and mapped, and the influence of energy accessibility on urban population growth was examined. Spatial patterns of energy accessibility have not varied a great deal despite the intense sectoral and spatial shifts in energy production. Energy accessibility has had a limited effect on urban population growth because other factors more profoundly influence Soviet urban population and because Soviet regional development policy appears to follow a course relatively unrestrained by energy resource locations. Although this work cannot be considered exhaustive, it has provided some additional insight on the interrelationship between energy accessibility and human activity in the Soviet Union.

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APPENDICES

APPENDIX A

DISTANCES TO COAL SOURCES

DISTANCES TO 1960 COAL SOURCES IN 100 KM

NODE	PECHORA	TULA	ROSTOV	UKRAINE	LVOV	DNEPER	GEORGIA	BASHKIR	PERM	SEROV	KORKINO	KUZNETSK	KA	ABAKAN	CHRMKOVO	AZEY	BURYAT	CHITA	YAKUTSK	AMUR	URGAL	MARITIME	SAKHALIN	MAGADAN	KARAGNDA	EKIBASTU	ANGREN	FERGANA
LENINGRAD	23	9	18	18	14	15	28	25	19	22	23	39	44	44	53	51	60	66	87	84	88	96	101	110	37	35	41	45
MURMANSK	25	19	28	30	26	27	39	35	25	28	29	45	51	51	59	57	66	72	92	90	94	102	107	116	41	41	52	56
PETROZAVODSK	24	10	19	21	18	19	30	26	21	24	26	41	46	47	56	53	62	68	89	86	90	98	103	113	37	37	43	47
NOVGOROD	23	7	16	17	13	14	27	23	20	23	24	39	44	45	54	51	61	66	87	84	88	96	102	111	35	36	40	44
VOLOGDA	17	7	16	16	18	16	27	21	13	16	17	33	38	38	47	45	54	60	80	77	81	90	95	104	29	29	37	41
ARKHANGELSK	19	13	22	23	25	22	33	27	18	21	23	38	43	44	53	50	60	65	86	83	87	95	100	110	34	34	44	48
SYKTYVKAR	10	16	25	25	27	25	36	26	14	17	18	34	38	39	48	46	55	60	81	78	82	90	96	105	29	30	43	47
MOSCOW	22	2	11	11	13	11	22	18	16	19	19	35	40	40	49	47	56	62	83	79	84	92	97	106	30	31	34	38
YAROSLAVL	19	5	14	14	16	13	24	19	14	17	18	34	38	39	48	45	55	60	81	78	82	90	96	105	29	30	35	39
VLADIMIR	22	4	13	13	15	14	24	17	14	17	18	34	39	39	48	46	56	61	81	78	82	91	96	105	29	30	33	37
IVANOVO	22	5	14	15	16	14	25	17	14	17	18	34	39	39	48	46	54	61	81	78	82	91	96	105	29	30	33	37
KALININ	23	4	13	13	15	12	23	19	17	20	21	37	42	43	52	49	58	64	85	82	86	94	99	109	32	33	36	40
KALUGA	24	1	12	11	12	9	23	19	18	21	21	37	41	42	51	48	58	63	84	81	85	93	99	108	32	33	34	38
KOSTROMA	21	6	15	15	18	15	26	19	13	16	17	33	37	38	47	44	54	59	80	77	81	89	95	104	28	29	35	39
RYAZAN	24	3	9	10	15	13	20	16	18	21	18	36	40	41	50	47	57	62	83	80	84	92	98	107	30	31	32	36
TULA	24	1	11	9	13	10	21	18	18	22	20	37	42	42	51	49	58	64	84	81	85	94	99	108	32	33	33	37
KAZAN	22	10	16	16	22	19	25	12	9	12	11	27	32	32	41	49	48	54	74	71	75	84	89	98	32	23	29	33
GORKIY	20	6	15	16	18	15	24	15	11	14	16	31	36	37	46	43	52	58	79	76	80	88	94	103	27	27	32	36
KIROV	14	11	20	20	22	20		19	7	10	11	27	31	32	41	39	48	53	74	71	75	79	89	98	22	23	36	40
YOSHKAR_OLA	24	11	17	17	22	19	25	12	10	13	13	28	33	34	43	40	49	55	76	73	77	83	91	100	24	24	30	34
SARANSK	23	8	12	12	20	16	23	12	13	16	14	31	36	36	46	43	52	57	79	76	80	88	93	102	26	27	28	32
CHEBOKSARY	23	9	15	15	20	17	25	12	10	13	13	29	33	34	43	40	49	55	76	73	77	85	91	100	24	24	29	33
ULYANOVSK	25	10	13	14	22	18	22	9	11	15	11	28	33	34	43	40	49	55	76	72	77	85	91	100	23	24	31	35
BELGOROD	29	5	6	4	11	6	16	21	25	28	24	41	46	46	55	53	62	68	88	85	89	98	103	112	34	35	35	40
VORONEZH	27	5	6	6	13	8	16	18	21	24	20	37	42	43	52	49	58	64	85	82	86	94	99	108	30	31	32	36
KURSK	27	3	7	6	10	7	18	20	21	24	22	40	44	45	54	51	61	66	87	84	88	96	102	111	33	33	35	39
OREL	25	2	9	8	11	7	19	20	20	23	22	39	44	44	53	51	60	66	86	83	87	96	101	110	32	33	34	38
BRYANSK	25	3	9	8	10	7	20	21	20	23	23	39	44	44	53	51	60	66	86	83	87	96	101	110	33	34	35	39
LIPETSK	27	3	7	7	14	10	18	17	20	23	19	36	41	42	51	48	57	63	84	81	85	93	99	108	30	30	31	35
TAMBOV	26	4	8	8	16	12	19	15	18	21	17	35	39	40	49	46	55	61	82	79	83	91	97	106	28	32	30	34
PENZA	24	6	10	11	19	14	21	12	15	18	14	31	36	37	46	43	52	58	79	76	80	88	93	102	24	25	28	32
ASTRAKHAN	34	14	10	11	23	17	15	19	23	26	21	39	43	44	53	49	60	65	86	83	87	95	101	110	29	30	29	33
VOLGOGRAD	32	10	4	6	19	12	13	17	21	24	19	36	41	41	50	48	57	63	83	80	84	93	98	107	29	29	30	34
KUYBYSHEV	27	10	13	13	23	18	22	8	12	15	10	27	32	33	49	46	48	54	75	72	76	84	89	98	21	21	24	28
SARATOV	28	7	9	11	19	15	18	12	16	19	14	31	36	37	46	42	52	58	79	76	80	88	93	102	24	25	26	30
ROSTOV	34	12	1	2	15	9	10	22	26	29	24	42	46	47	56	53	63	68	90	86	90	98	104	113	34	35	35	39
KRASNODAR	37	15	5	6	19	13	9	24	28	31	26	43	48	49	48	45	64	70	91	88	92	100	105	114	36	36	34	38
STAVROPOL	38	16	5	6	19	13	9	24	28	31	26	44	48	49	58	55	65	70	91	88	92	100	106	115	36	37	34	38
MAKHACHKALA	40	20	10	11	24	18	11	25	29	32	27	44	49	49	58	56	65	71	92	89	93	101	106	115	35	35	26	30
NALCHIK	40	18	7	9	22	15	12	26	29	32	28	45	50	53	59	57	66	72	92	89	93	102	107	116	39	36	30	34
ORDZHONIKIDZE	41	19	8	9	21	16	12	25	29	32	27	45	49	50	59	56	66	71	92	89	93	101	107	116	38	36	29	30
GROZNYY	40	19	9	10	23	16	12	24	28	32	26	43	48	49	47	45	63	70	91	88	92	100	105	114	34	35	28	28
KIEV	30	8	9	7	6	4	19	24	24	27	27	44	48	49	58	55	65	70	91	88	92	100	106	115	38	38	39	43

DISTANCES TO 1960 COAL SOURCES IN 100 KM

NODE	PECHORA	TULA	ROSTOV	UKRAINE	LVOV	DNEPER	GEORGIA	BASHKIR	PERM	SEROV	KORKINO	KUZNETSK	KA	ABAKAN	CHRMKOVO	AZEY	BURYAT	CHITA	YAKUTSK	AMUR	URGAL	MARITIME	SAKHALIN	MAGADAN	KARAGNDA	EKIBASTU	ANGREN	FERGANA
ZAPOROZH'E	33	9	6	3	11	5	15	21	27	30	27	44	49	49	58	56	65	71	91	88	92	101	106	115	37	38	39	43
KHARKOV	29	6	6	3	11	5	15	20	24	27	23	41	45	46	55	52	62	67	88	85	89	97	102	111	34	35	36	40
LVOV	35	13	16	14	1	8	25	30	28	32	33	49	53	54	63	60	70	75	96	93	97	105	111	120	44	44	45	49
KISHINEV	36	14	13	11	7	4	22	30	26	34	33	50	55	55	63	62	71	77	97	94	98	107	112	121	43	44	45	49
TALLIN	26	12	21	19	14	17	31	28	27	26	27	43	47	48	57	55	64	69	90	87	91	99	105	114	38	39	44	48
RIGA	28	11	19	17	11	14	29	27	28	27	28	44	49	49	58	56	65	71	92	89	93	101	106	115	39	40	43	47
VILNIUS	30	10	16	14	7	10	26	27	25	28	29	45	49	50	59	56	66	71	92	89	93	101	107	116	40	41	43	47
KALININGRAD	33	13	20	17	11	14	29	31	28	31	32	48	53	53	63	60	69	75	96	93	97	105	110	119	43	44	46	50
SMOLENSK	26	4	13	11	10	9	23	22	23	23	24	39	44	45	53	51	60	66	87	84	88	96	101	110	34	35	37	41
PSKOV	25	9	18	16	12	14	28	25	24	24	25	41	46	46	55	53	62	68	88	86	89	98	103	112	36	37	41	45
MINSK	29	8	14	12	7	9	24	25	25	26	27	43	47	48	57	54	64	69	90	87	91	99	106	115	38	39	41	45
TBILISI	45	23	13	14	27	20	2	32	26	38	34	51	56	57	65	63	72	78	99	96	100	108	113	122	41	44	28	28
BAKU	44	24	14	15	28	22	7	28	29	35	31	48	53	52	62	60	69	75	95	92	96	105	110	119	36	39	23	23
YEREVAN	49	27	17	18	31	24	6	35	29	42	37	55	59	60	69	66	75	81	102	98	103	111	117	126	45	46	29	30
LUTSK	34	11	14	12	2	8	24	30	29	31	32	47	52	53	62	59	68	74	96	92	97	104	109	118	42	42	44	48
ROVNO	33	11	13	11	2	7	23	29	30	30	31	47	51	52	61	58	68	73	95	91	96	103	109	118	41	42	43	47
UZHGOROD	36	14	17	14	3	9	26	32	26	34	34	51	55	56	65	62	72	77	98	95	99	107	113	122	45	45	46	50
IVANO_FRANKOVSK	36	14	16	14	2	8	26	30	26	33	32	50	55	55	64	62	71	77	97	94	98	107	112	121	45	45	46	50
TERNOPOL	34	12	15	12	2	6	24	28	28	31	31	47	52	53	62	59	68	74	96	92	97	104	110	119	43	43	44	48
ZHITOMIR	32	9	12	9	4	4	21	25	26	29	27	45	50	51	60	57	66	72	93	90	94	102	108	117	40	40	41	45
VINNITSA	32	10	12	10	4	4	21	26	27	30	28	46	50	51	60	58	67	72	93	90	94	102	108	117	40	41	41	45
KHMELNITSKIY	34	11	14	11	3	4	23	27	28	31	29	47	52	53	61	59	68	74	95	92	96	104	109	118	41	42	43	47
CHERNOVSTY	36	14	16	13	3	7	25	31	30	33	33	50	54	55	64	62	70	76	97	94	98	106	112	121	44	44	45	49
CHERNIGOV	29	7	10	8	6	5	20	23	23	26	27	43	47	48	57	54	64	69	90	87	91	99	105	114	37	38	39	43
SUMY	29	6	8	6	9	5	17	23	23	26	25	42	47	47	56	54	63	69	89	86	90	99	104	113	35	36	37	41
POLTAVA	31	7	6	4	9	3	16	22	24	27	24	44	49	50	58	56	65	71	92	89	93	101	106	115	36	36	37	41
CHERKASSY	31	9	8	5	7	1	18	25	25	28	27	45	49	50	59	57	66	70	92	89	93	101	107	116	39	39	40	44
KIROVOGRAD	32	10	9	7	8	1	18	25	26	29	27	46	50	51	60	57	67	72	93	90	94	102	108	117	39	40	41	45
ODESSA	35	13	11	9	7	3	18	28	29	32	30	49	53	54	63	60	69	75	96	93	97	105	111	120	42	42	44	48
NIKOLAYEV	35	12	9	6	10	3	16	26	29	32	28	47	51	52	61	58	68	73	94	91	95	103	109	118	40	40	41	45
KHERSON	35	12	9	6	11	3	15	26	27	32	29	46	51	51	60	58	67	73	93	91	94	103	108	117	40	40	41	45
SIMFEROPOL	36	13	10	6	13	6	14	25	30	33	30	48	52	53	62	59	69	74	95	92	96	104	110	119	41	41	42	46
DNEPROPETROVSK	32	8	6	3	11	4	15	23	26	29	26	43	48	48	57	55	64	70	90	87	91	100	105	114	36	37	38	42
DONETSK	33	9	2	1	14	7	14	22	26	29	25	42	47	47	56	54	63	68	89	86	90	98	104	113	35	36	37	41
VOROSHILOVGRAD	32	9	1	1	14	8	12	22	25	28	24	41	46	46	55	53	62	68	88	84	89	98	103	112	34	34	37	41
GRODNO	32	11	18	15	7	12	27	29	27	30	30	46	51	51	62	59	67	73	93	90	94	103	108	117	41	42	44	48
VITEBSK	27	6	14	12	10	9	24	23	21	24	25	41	45	46	55	52	62	67	88	85	89	97	103	112	36	36	38	42
MOGILEV	26	6	13	10	8	8	23	24	22	25	25	41	46	47	55	53	62	68	89	86	90	98	103	112	36	37	39	43
GOMEL	28	6	11	9	7	6	21	24	22	25	26	42	46	47	56	53	64	68	89	86	90	98	104	113	36	37	38	42
BREST	33	11	17	13	3	9	25	29	27	30	30	46	51	51	60	58	67	73	93	90	94	103	108	117	41	42	43	47
UFA	31	15	19	20	28	22	27	3	10	10	5	22	27	27	36	34	43	49	69	46	70	79	84	93	17	18	28	32
IZHEVSK	19	13	20	20	25	22	28	13	6	9	9	24	29	30	38	36	45	51	72	69	73	81	86	95	21	21	33	37
ORENBURG	31	14	18	19	27	20	25	11	17	15	8	26	30	31	40	38	47	52	73	70	74	83	88	97	17	17	20	24

DISTANCES TO 1960 COAL SOURCES IN 100 KM

NODE	PECHORA	TULA	ROSTOV	UKRAINE	LVOV	DNEPER	GEORGIA	BASHKIR	PERM	SEROV	KORKINO	KUZNETSK	KA	ABAKAN	CHRMKOVO	AZEY	BURYAT	CHITA	YAKUTSK	AMUR	URGAL	MARITIME	SAKHALIN	MAGADAN	KARAGANDA	EKIBASTU	ANGREN	FERGANA
PERM	19	16	24	24	27	24	32	11	2	5	6	22	27	27	36	34	43	49	69	66	70	79	84	93	17	18	30	34
SVERDLOVSK	23	19	26	25	30	28	33	9	4	4	4	18	23	24	32	30	39	45	66	63	67	75	80	89	14	14	26	30
CHELYABINSK	26	20	24	25	33	27	32	7	8	8	1	17	22	23	31	29	38	44	65	62	66	74	79	88	12	13	24	28
TYUMEN	27	22	29	28	34	31	36	12	7	7	6	15	20	20	29	27	36	42	62	89	63	72	77	86	15	16	29	33
KURGAN	27	22	27	27	34	31	35	10	8	8	3	15	19	20	29	26	36	41	62	59	63	71	77	86	10	11	26	30
OMSK	32	28	32	33	39	36	40	15	13	13	7	9	14	15	23	21	30	36	67	54	58	66	71	80	10	11	26	30
NOVOSIBIRSK	39	34	39	39	46	43	46	22	19	19	14	3	8	8	17	15	24	30	50	47	51	60	65	74	14	9	28	32
TOMSK	42	37	42	42	49	46	49	25	22	22	17	3	6	9	16	13	23	28	49	46	50	58	64	73	17	11	31	35
BARNAUL	42	37	42	42	48	46	49	25	22	22	17	5	11	7	20	18	27	33	53	50	54	63	68	77	12	7	26	30
KRASNOYARSK	46	42	46	47	53	50	54	29	27	27	22	7	1	6	9	7	16	22	43	40	44	52	58	67	22	16	35	39
IRKUTSK	57	53	57	57	64	61	65	40	38	38	33	18	11	13	1	4	6	11	32	29	33	41	47	56	32	26	45	49
CHITA	67	63	67	67	74	71	75	50	48	48	43	28	21	23	11	14	7	1	22	19	23	31	37	46	42	36	56	60
ABAKAN	47	42	47	47	54	51	55	30	28	28	23	7	6	1	12	9	23	24	49	46	50	58	64	73	19	13	32	36
KEMEROVO	41	37	42	42	49	46	49	25	22	22	17	1	7	7	17	15	24	29	50	47	51	60	65	74	16	10	30	34
ULAN_UDE	62	57	62	62	69	65	69	45	42	42	37	23	15	22	6	7	1	7	27	24	28	37	42	51	36	31	50	54
VLADIVOSTOK	99	94	99	99	106	103	106	82	79	79	74	60	52	59	43	45	38	30	31	13	14	1	22	31	73	68	87	91
KHABAROVSK	90	86	90	91	97	94	98	74	71	71	66	52	44	51	35	37	30	22	23	5	6	8	14	23	65	60	79	83
BLAGOVESHCHENSK	85	80	85	85	92	89	93	48	66	66	61	46	39	45	29	32	24	17	17	3	8	16	21	30	60	54	74	78
YUZHNO_SAKHALINSK	102	97	102	102	109	106	109	85	82	82	77	63	56	62	46	48	41	34	34	16	12	20	2	18	76	71	90	94
MAGADAN	106	101	106	106	113	110	113	89	87	87	82	67	60	66	50	53	45	38	36	20	17	24	13	7	81	75	95	99
YAKUTSK	89	84	90	89	96	93	97	72	69	70	65	50	43	49	33	36	28	21	1	14	22	30	36	43	64	59	78	82
PETROPAVLOVSK_KAM	118	105	105	109	115	113	116	92	89	89	84	70	62	69	53	55	48	40	39	22	19	27	15	15	83	78	97	101
GURYEV	40	23	25	26	34	30	33	20	19	19	13	30	35	36	45	43	51	57	78	75	79	87	91	101	21	21	23	26
AKTYUBINSK	35	18	20	21	29	25	27	15	14	14	8	25	30	30	39	37	46	52	72	69	73	82	86	96	16	16	17	20
URALSK	32	12	14	15	24	19	22	15	18	18	12	29	34	35	43	41	50	56	77	74	78	86	91	101	20	20	21	25
KUSTANAY	28	23	26	27	35	31	34	30	9	9	2	18	23	23	32	30	39	45	66	63	67	75	80	90	10	10	23	27
PETROPAVLOVSK	30	25	30	37	37	34	37	10	10	10	5	12	17	17	26	24	32	39	59	56	60	69	74	83	7	8	23	27
KOKCHETAV	32	27	30	31	39	35	38	15	12	12	7	14	19	19	28	26	35	41	61	58	62	71	76	85	6	6	21	25
TSELINOGRAD	34	30	32	33	41	36	39	14	15	15	10	14	19	16	28	26	35	40	61	58	62	71	76	85	3	3	18	22
KARAGANDA	37	32	34	35	44	39	41	20	18	18	12	16	22	19	30	28	37	43	63	61	65	73	78	87	1	6	16	20
KZYL_ORDA	44	27	29	30	39	34	34	24	24	24	17	31	37	34	46	43	52	56	79	76	80	88	94	101	17	16	6	10
CHIMKENT	49	32	34	35	43	39	31	29	28	28	22	26	32	29	41	38	48	56	74	71	75	83	89	98	12	17	3	7
DZHAMBUL	51	34	36	37	45	41	33	31	31	31	24	24	30	27	39	36	46	51	72	69	73	81	87	96	10	16	6	9
SEMIPALATINSK	45	40	45	46	52	50	49	28	25	25	20	9	14	11	23	21	30	36	56	53	57	66	71	80	16	10	21	25
PAVLODAR	39	34	36	37	46	41	49	22	20	20	14	9	15	12	24	21	31	36	58	54	58	66	72	81	7	1	25	29
UST_KAMENOGORSK	46	41	46	47	53	42	52	29	27	27	22	10	15	13	24	22	31	37	58	54	59	67	72	81	9	12	25	29
ALMA_ATA	48	39	42	44	51	47	39	31	28	28	23	19	25	21	33	31	40	46	67	64	68	76	82	91	11	16	11	15
ASHKHABAD	50	29	21	24	36	30	16	42	42	42	35	41	47	44	56	53	63	69	89	86	90	99	104	113	27	33	14	18
DUSHANBE	63	44	35	38	51	44	30	42	42	42	35	42	47	44	56	53	63	69	89	86	90	99	104	113	27	33	14	15
TASHKENT	50	32	34	36	44	40	29	30	29	29	23	27	34	31	43	41	50	56	77	74	78	86	91	100	15	20	1	5
FRUNZE	47	36	39	41	48	44	36	31	28	28	23	25	30	27	39	36	46	52	72	70	74	82	87	96	11	16	8	12
ELISTA	40	18	7	9	22	16	11	27	31	34	30	46	51	51	60	58	67	73	93	90	94	103	108	117	39	39	37	41

DISTANCES TO 1970/1975 COAL SOURCES IN 100 KM

NODE	PECHORA	TULA	ROSTOV	UKRAINE	LVOV	DNEPER	GEORGIA	BASHKIR	PERM	SEROV	KORKINO	KUZNETSK	KA	ABAKAN	CHRMKOVO	AZEY	BURYAT	CHITA	YAKUTSK	AMUR	URGAL	MARITIME	SAKHALIN	MAGADAN	KARAGNDA	EKIBASTU	ANGREN	FERGANA
LENINGRAD	23	9	18	18	14	15	28	25	19	22	23	39	44	44	53	51	60	66	87	84	88	96	101	110	27	35	41	45
MURMANSK	25	19	28	30	26	27	39	35	25	28	29	45	51	51	59	57	65	72	92	93	94	132	107	115	41	41	52	56
PETROZAVODSK	24	10	19	21	18	19	30	26	21	24	26	41	46	47	56	53	62	68	89	86	90	98	103	113	37	37	43	47
NOVGOROD	23	7	16	17	13	14	27	23	20	23	24	39	44	45	54	51	61	65	87	84	88	96	102	111	35	36	40	44
VOLOGDA	17	7	16	16	18	16	27	21	13	16	17	33	38	38	47	45	54	60	80	77	81	90	95	104	29	29	37	41
ARKHANGELSK	19	13	22	23	25	22	33	27	18	21	23	38	43	44	53	50	60	65	86	83	87	95	100	110	34	34	44	48
SYKTYVKAR	10	16	25	25	27	25	36	26	14	17	18	34	38	39	48	46	55	60	81	78	82	90	95	105	29	30	43	47
MOSCOW	22	2	11	11	13	11	22	18	16	19	19	35	40	40	49	47	56	62	83	79	84	92	97	106	30	31	34	38
YAROSLAVL	19	5	14	14	16	13	24	19	14	17	18	34	38	39	48	45	55	50	81	78	82	90	96	105	29	30	35	39
VLADIMIR	22	4	13	13	15	14	24	17	14	17	18	34	39	39	48	46	56	61	81	79	82	91	96	105	29	30	33	37
IVANOVO	22	5	14	15	16	14	25	17	14	17	18	34	39	39	48	46	54	61	81	78	82	91	96	105	29	30	33	37
KALININ	23	4	13	13	15	12	23	19	17	20	21	37	42	43	52	49	58	64	85	82	86	94	99	109	32	33	36	40
KALUGA	24	1	12	11	12	9	23	19	18	21	21	37	41	42	51	48	58	63	84	81	85	93	99	108	32	33	34	38
KOSTROMA	21	6	15	15	18	15	26	19	13	16	17	33	37	38	47	44	54	59	80	77	81	89	95	104	28	29	35	39
RYAZAN	24	3	9	10	15	13	20	16	18	21	18	36	40	41	50	47	57	62	83	80	84	92	98	107	30	31	32	36
TULA	24	1	11	9	13	10	21	18	18	22	20	37	42	42	51	49	58	64	84	81	85	94	99	108	32	33	33	37
KAZAN	22	10	16	16	22	19	25	12	9	12	11	27	32	32	41	49	48	56	74	71	75	84	89	98	32	23	29	33
GORKIY	20	6	15	16	18	15	26	15	11	14	16	31	36	37	46	43	52	58	79	76	80	88	94	103	27	27	32	36
KIROV	14	11	20	20	22	20	30	19	7	10	11	27	31	32	41	39	48	53	74	71	75	79	89	98	22	23	36	40
YOSHKAR_OLA	24	11	17	17	22	19	25	12	10	13	13	28	33	34	43	40	49	55	75	73	77	83	91	100	24	24	30	34
SARANSK	23	8	12	12	20	16	23	12	13	15	14	31	36	36	46	43	52	57	79	76	80	88	93	102,	26	27	28	32
CHEBOKSARY	23	9	15	15	20	17	25	12	10	13	13	29	33	34	43	40	49	55	75	73	77	85	91	100	24	24	29	33
ULYANOVSK	25	10	13	14	22	18	22	9	11	15	11	28	33	34	43	40	49	55	76	72	77	85	91	100	23	24	31	35
BELGOROD	29	5	6	4	11	6	16	21	25	28	24	41	46	46	55	53	62	68	88	85	89	98	103	112	34	35	36	40
VORONEZH	27	5	6	6	13	8	16	18	21	24	20	37	42	43	52	49	58	64	85	82	96	94	99	108	30	31	32	36
KURSK	27	3	7	6	10	7	18	20	21	24	22	40	44	45	54	51	61	66	87	84	88	96	102	111	33	33	35	39
OREL	25	2	9	8	11	7	19	20	20	23	22	39	44	44	53	51	60	66	86	83	87	96	101	110	32	33	34	38
BRYANSK	25	3	9	8	10	7	20	21	20	23	23	39	44	44	53	51	60	66	85	83	87	96	101	110	33	34	35	39
LIPETSK	27	3	7	7	14	10	18	17	20	23	19	35	41	42	51	48	57	63	84	81	85	93	99	108	30	30	31	35
TAMBOV	26	4	8	8	16	12	19	15	18	21	17	35	39	40	49	46	55	61	82	79	83	91	97	105	28	32	30	34
PENZA	24	6	10	11	19	14	21	12	15	18	14	31	36	37	46	43	52	58	79	76	80	88	93	102	24	25	28	32
ASTRAKHAN	34	14	10	11	23	17	15	19	22	22	15	33	38	39	48	46	54	60	81	78	82	91	94	104	24	24	26	27
VOLGOGRAD	32	10	4	6	19	12	13	17	21	24	19	36	41	41	50	48	57	63	83	80	84	93	98	107	28	28	30	31
KUYBYSHEV	27	10	13	13	23	18	22	8	15	15	10	27	32	33	49	46	48	54	75	72	76	84	89	98	21	21	24	28
SARATOV	28	7	9	11	19	15	18	12	16	19	14	31	36	37	46	42	52	58	79	76	80	88	93	102	24	25	26	30
ROSTOV	34	12	1	2	15	9	10	22	26	29	24	42	46	47	56	53	63	68	90	86	90	98	104	113	34	35	35	39
KRASNODAR	37	15	5	6	19	13	9	24	28	31	26	43	48	49	48	45	64	70	91	88	92	100	105	114	36	36	34	38
STAVROPOL	38	16	5	6	19	13	9	24	28	31	26	44	48	49	58	55	65	70	91	88	92	100	105	115	36	37	34	38
MAKHACHKALA	40	20	10	11	24	18	11	25	29	32	27	44	49	49	58	56	65	71	92	89	93	101	106	115	35	35	26	30
NALCHIK	40	18	7	9	22	15	12	26	29	32	28	45	50	53	59	57	65	72	92	89	93	102	107	116	39	36	30	34
ORDZHONIKIDZE	41	19	8	9	21	16	12	25	29	32	27	45	49	50	59	56	66	71	92	89	93	101	107	115	38	35	29	30
GROZNYY	40	19	9	10	23	16	12	24	28	32	26	43	48	49	4.	45	63	70	91	88	92	100	105	114	34	35	28	28
KIEV	30	8	9	7	6	4	19	24	24	27	27	44	48	49	59	55	65	70	91	88	92	100	106	115	38	38	39	43

DISTANCES TO 1970/1975 COAL SOURCES IN 100 KM

NODE	PECHORA	TULA	ROSTOV	UKRAINE	LVOV	DNEPER	GEORGIA	BASHKIR	PERM	SEROV	KORKINO	KUZNETSK	KA	ABAKAN	CHRMKOVO	AZEY	BURYAT	CHITA	YAKUTSK	AMUR	URGAL	MARITIME	SAKHALIN	MAGADAN	KARAGANDA	EKIBASTU	ANGREN	FERGANA
ZAPOROZHYE	33	9	6	3	11	5	15	21	27	30	27	44	49	49	58	56	65	71	91	88	92	101	106	115	37	38	39	43
KHARKOV	29	6	6	3	11	5	15	20	24	27	23	41	45	45	55	52	62	67	88	85	89	97	102	111	34	35	36	40
LVOV	35	13	16	14	1	8	25	30	28	32	33	49	53	54	63	60	70	75	96	93	97	105	111	120	44	44	45	49
KISHINEV	36	14	13	11	7	4	22	30	26	34	33	50	55	55	63	62	71	77	97	94	98	107	112	121	43	44	45	49
TALLIN	26	12	21	19	14	17	31	28	27	26	27	43	47	48	57	55	64	69	90	87	91	99	105	114	38	39	44	48
RIGA	28	11	19	17	11	14	29	27	28	27	28	44	49	49	58	56	65	71	92	89	93	101	106	115	39	40	43	47
VILNIJS	30	10	16	14	7	10	26	27	25	28	29	45	49	50	59	56	65	71	92	89	93	101	107	116	40	41	43	47
KALININGRAD	33	13	20	17	11	14	29	31	28	31	32	48	53	53	63	60	69	75	95	93	97	105	110	119	43	44	46	50
SMOLENSK	26	4	13	11	10	9	23	22	23	23	24	39	44	45	53	51	60	66	87	84	88	96	101	110	34	35	37	41
PSKOV	25	9	18	16	12	14	28	25	24	24	25	41	46	46	55	53	62	68	88	85	89	98	103	112	36	37	41	45
MINSK	29	8	14	12	7	9	24	25	25	26	27	43	47	48	57	54	64	69	90	87	91	99	105	115	38	39	41	45
TBILISI	45	23	13	14	27	20	2	32	26	38	34	51	56	57	65	63	72	78	99	95	100	108	113	122	41	44	28	28
BAKU	44	24	14	15	28	22	7	28	29	35	31	48	53	52	62	60	69	75	95	92	96	105	110	119	36	39	23	23
YEREVAN	49	27	17	18	31	24	6	35	29	42	37	55	59	60	69	66	76	81	102	98	103	111	117	126	45	46	29	30
LUTSK	34	11	14	12	2	8	24	30	29	31	32	47	52	53	62	59	68	74	96	92	97	104	109	118	42	42	44	48
ROVNO	33	11	13	11	2	7	23	29	30	30	31	47	51	52	61	58	68	73	95	91	96	103	109	118	41	42	43	47
UZHGOROD	36	14	17	14	3	9	26	32	26	34	34	51	55	56	65	62	72	77	98	95	99	107	113	122	45	45	46	50
IVANO_FRANKOVSK	36	14	16	14	2	8	26	30	26	33	32	50	55	55	64	62	71	77	97	94	98	107	112	121	45	45	46	50
TERNOPOL	34	12	15	12	2	6	24	28	28	31	31	47	52	53	62	59	68	74	96	92	97	104	110	119	43	43	44	48
ZHITOMIR	32	9	12	9	4	4	21	25	26	29	27	45	50	51	60	57	66	72	93	90	94	102	108	117	40	40	41	45
VINNITSA	32	10	12	10	4	4	21	26	27	30	28	46	50	51	60	58	67	72	93	90	94	102	108	117	40	41	41	45
KHMELNITSKIY	34	11	14	11	3	4	23	27	28	31	29	47	52	53	61	59	68	74	95	92	96	104	109	118	41	42	43	47
CHERNOVSTY	36	14	16	13	3	7	25	31	30	33	33	50	54	55	64	62	70	76	97	94	98	106	112	121	44	44	45	49
CHERNIGOV	29	7	10	8	6	5	20	23	23	26	27	43	47	48	57	54	64	69	90	87	91	99	105	114	37	38	39	43
SUMY	29	6	8	6	9	5	17	23	23	26	25	42	47	47	56	54	63	69	89	86	90	99	104	113	35	36	37	41
POLTAVA	31	7	6	4	9	3	16	22	24	27	24	44	49	50	58	56	65	71	92	89	93	101	106	115	36	36	37	41
CHERKASSY	31	9	8	5	7	1	18	25	25	28	27	45	49	50	59	57	66	70	92	89	93	101	107	116	39	39	40	44
KIROVOGRAD	32	10	9	7	8	1	18	25	26	29	27	46	50	51	60	57	67	72	93	90	94	102	108	117	39	40	41	45
ODESSA	35	13	11	9	7	3	18	28	29	32	30	49	53	54	63	60	69	75	96	93	97	105	111	120	42	42	44	48
NIKOLAYEV	35	12	9	6	10	3	16	26	29	32	28	47	51	52	61	58	68	73	94	91	95	103	109	118	40	40	41	45
KHERSON	35	12	9	6	11	3	15	26	27	32	29	46	51	51	60	58	67	73	93	91	94	103	108	117	40	40	41	45
SIMFEROPOL	36	13	10	6	13	6	14	25	30	33	30	48	52	53	62	59	69	74	95	92	96	104	110	119	41	41	42	46
DNEPROPETROVSK	32	8	6	3	11	4	15	23	26	29	26	43	48	48	57	55	64	70	90	87	91	100	105	114	36	37	38	42
DONETSK	33	9	2	1	14	7	14	22	26	29	25	42	47	47	56	54	63	68	89	86	90	98	104	113	35	36	37	41
VOROSHILOVGRAD	32	9	1	1	14	8	12	22	25	28	24	41	46	46	55	53	62	68	88	84	89	98	103	112	34	34	37	41
GRODNO	32	11	18	15	7	12	27	29	27	30	30	46	51	51	62	59	67	73	93	90	94	103	108	117	41	42	44	48
VITEBSK	27	6	14	12	10	9	24	23	21	24	25	41	45	46	55	52	62	67	88	85	89	97	103	112	36	36	38	42
MOGILEV	26	6	13	10	8	8	23	24	22	25	25	41	46	47	55	53	62	68	89	86	90	98	103	112	36	37	39	43
GOMEL	28	6	11	9	7	6	21	24	22	25	26	42	46	47	56	53	64	68	89	86	90	98	104	113	36	37	38	42
BREST	33	11	17	13	3	9	25	29	27	30	30	45	51	51	60	58	67	73	93	90	94	103	108	117	41	42	43	47
UFA	31	15	19	20	28	22	27	3	10	10	5	22	27	27	36	34	43	49	69	66	70	79	84	93	17	18	28	32
IZHEVSK	19	13	20	20	25	22	28	13	6	9	9	24	29	30	38	36	45	51	72	69	73	81	86	95	21	21	33	37
ORENBURG	31	14	18	19	27	20	25	11	17	15	8	26	30	31	40	38	47	52	73	70	74	83	88	97	17	17	20	24

DISTANCES TO 1970/1975 COAL SOURCES IN 100 KM

NODE	PECHORA	TULA	ROSTOV	UKRAINE	LVOV	DNEPER	GEORGIA	BASHKIR	PERM	SEROV	KORKINO	KUZNETSK	KA	ABAKAN	CHRMKOVO	AZEY	BURYAT	CHITA	YAKUTSK	AMUR	URGAL	MARITIME	SAKHALIN	MAGADAN	KARAGANDA	EKIBASTUZ	ANGREN	FERGANA
PERM	19	16	24	24	27	24	32	11	2	5	6	22	27	27	36	34	43	49	69	66	70	79	84	93	17	18	30	34
SVERDLOVSK	23	19	26	25	30	28	33	9	4	4	4	18	23	24	32	30	39	45	56	63	67	75	80	89	14	14	26	30
CHELYABINSK	26	20	24	25	33	27	32	7	8	8	1	17	22	23	31	29	38	44	65	62	66	74	79	88	12	13	24	28
TYUMEN	27	22	29	28	34	31	36	12	7	7	6	15	20	20	29	27	36	42	62	89	63	72	77	86	15	16	29	33
KURGAN	27	22	27	27	34	31	35	10	8	8	3	15	19	20	29	26	36	41	62	59	63	71	77	86	10	11	26	30
OMSK	32	28	32	33	39	36	40	15	13	13	7	9	14	15	23	21	30	36	67	54	58	66	71	80	10	11	26	30
NOVOSIBIRSK	39	34	39	39	46	43	46	22	19	19	14	3	8	8	17	15	24	30	50	47	51	60	65	74	14	9	28	32
TOMSK	42	37	42	42	49	46	49	25	22	22	17	3	6	9	16	13	23	28	49	46	50	58	64	73	17	11	31	35
BARNAUL	42	37	42	42	48	46	49	25	22	22	17	5	11	7	20	18	27	33	53	50	54	63	68	77	12	7	26	30
KRASNOYARSK	46	42	46	47	53	50	54	29	27	27	22	7	1	6	9	7	15	22	43	40	44	52	58	67	22	16	35	39
IRKUTSK	57	53	57	57	64	61	65	40	38	38	33	18	11	13	1	4	6	11	32	29	33	41	47	56	32	26	45	49
CHITA	67	63	67	67	74	71	75	50	48	43	43	28	21	23	11	14	7	1	22	19	23	31	37	46	42	36	56	60
ABAKAN	47	42	47	47	54	51	55	30	28	28	23	7	5	1	12	9	23	24	49	46	50	58	64	73	19	13	32	36
KEMEROVO	41	37	42	42	49	46	49	25	22	22	17	1	7	7	17	15	24	29	50	47	51	60	65	74	16	10	30	34
ULAN_UDE	62	57	62	62	69	65	69	45	42	42	37	23	15	22	6	7	1	7	27	24	28	37	42	51	36	31	50	54
VLADIVOSTOK	99	94	99	99	106	103	106	82	79	79	74	60	52	59	43	45	38	30	31	13	14	1	22	31	73	68	87	91
KHABAROVSK	90	86	90	91	97	94	98	74	71	71	66	52	44	51	35	37	30	22	23	5	6	8	14	23	65	60	79	83
BLAGOVESHCHENSK	85	80	85	85	92	89	93	48	66	66	61	46	39	45	29	32	24	17	17	3	8	16	21	30	60	54	74	78
YUZHNO_SAKHALINSK	102	97	102	102	109	106	109	85	82	82	77	63	56	62	46	48	41	34	34	16	12	20	2	18	76	71	90	94
MAGADAN	106	101	106	106	113	110	113	89	87	87	82	67	60	66	50	53	45	38	36	20	17	24	13	7	81	75	95	99
YAKUTSK	89	84	90	89	96	93	97	72	69	70	65	50	43	49	33	36	28	21	1	14	22	30	36	43	64	59	78	82
PETROPAVLOVSK_KAM	118	105	108	109	115	113	116	92	89	89	84	70	62	69	53	55	48	40	39	22	19	27	15	15	83	78	97	101
GURYEV	37	17	13	14	26	20	18	20	19	19	13	30	35	36	45	43	51	57	78	75	79	87	91	101	21	21	23	24
AKTYUBINSK	35	18	19	20	29	25	24	15	14	14	8	25	30	30	39	37	46	52	72	69	73	82	86	96	16	16	17	20
URALSK	32	12	14	15	24	19	22	15	18	18	12	29	34	35	43	41	50	56	77	74	78	86	91	101	20	20	21	25
KUSTANAY	28	23	26	27	35	31	34	30	9	9	2	18	23	23	32	30	39	45	66	63	57	75	80	90	10	10	23	27
PETROPAVLOVSK	30	25	30	37	37	34	37	10	10	10	5	12	17	17	26	24	32	39	59	56	60	69	74	83	7	8	23	27
KOKCHETAV	32	27	30	31	39	35	38	15	12	12	7	14	19	19	28	25	35	41	51	58	62	71	76	85	6	6	21	25
TSELINOGRAD	34	30	32	33	41	36	39	14	15	15	10	14	19	16	28	26	35	40	61	58	62	71	76	85	3	3	18	22
KARAGANDA	37	32	34	35	44	39	41	20	18	18	12	16	22	19	30	28	37	43	63	61	65	73	78	87	1	6	16	20
KZYL_ORDA	44	27	29	30	39	34	34	24	24	24	17	31	37	34	46	43	52	58	79	76	80	88	94	101	17	16	6	10
CHIMKENT	49	32	34	35	43	39	31	29	28	28	22	26	32	29	41	38	48	56	74	71	75	83	89	98	12	17	3	7
DZHAMBUL	51	34	36	37	45	41	33	31	31	31	24	24	30	27	39	36	46	51	72	69	73	81	87	96	10	16	6	9
SEMIPALATINSK	45	40	45	46	52	50	49	28	25	25	20	9	14	11	23	21	30	36	56	53	57	66	71	80	16	10	21	25
PAVLODAR	39	34	36	37	46	41	49	22	20	20	14	9	15	12	24	21	31	36	58	54	58	66	72	81	7	1	25	29
UST_KAMENOGORSK	46	41	46	47	53	42	52	29	27	27	22	10	15	13	24	22	31	37	58	54	59	67	72	81	9	12	25	29
ALMA_ATA	48	39	42	44	51	47	39	31	28	28	23	19	25	21	33	31	40	46	67	64	68	76	82	91	11	16	11	15
ASHKHABAD	50	29	21	24	36	30	16	42	42	42	35	41	47	44	56	53	63	69	89	86	90	99	104	113	27	33	14	18
DUSHANBE	63	44	35	38	51	44	30	42	42	42	35	42	47	44	56	53	63	69	89	86	90	99	104	113	27	33	14	15
TASHKENT	50	32	34	36	44	40	29	30	29	29	23	27	34	31	43	41	50	56	77	74	78	86	91	100	15	20	1	5
FRUNZE	47	36	39	41	48	44	36	31	28	28	23	25	30	27	39	36	46	52	72	70	74	82	87	96	11	16	8	12
ELISTA	40	18	7	9	22	16	11	27	31	34	30	46	51	51	60	58	67	73	93	90	94	103	108	117	39	39	37	41

APPENDIX B

DISTANCES TO OIL SOURCES

DISTANCES TO 1960 OIL SOURCES IN 100 KM

NODE	KOMI	KRASNODR	STAVROPL	GROZNYY	DAGESTAN	TATAR	BASHKIR	KUBYSHEV	SARATOV	VOLGOGRD	PERM	ORENBURG	W UKRAIN	BAKU	SAKHALIN	EMBA60	FERGANA	TURKMEN
LENINGRAD	17	23	29	27	28	17	18	17	15	16	17	19	16	31	98	30	45	36
MURMANSK	20	33	39	37	38	28	29	28	26	27	23	30	28	42	104	35	56	47
PETROZAVODSK	19	24	30	28	29	19	20	19	17	18	19	21	20	33	100	32	47	38
NOVGOROD	18	21	27	25	26	16	17	16	14	15	18	18	16	30	98	29	44	35
VOLOGDA	9	21	27	25	26	12	13	14	14	15	11	16	20	30	92	27	41	35
ARKHANGELSK	13	27	32	30	32	19	20	20	20	21	16	22	26	36	97	33	48	41
SYKTYVKAR	4	30	34	32	32	17	18	20	20	21	12	22	29	36	93	33	47	41
MOSCOW	16	16	22	20	21	10	11	11	9	10	14	13	16	25	95	24	38	30
YAROSLAVL	13	19	25	23	24	10	12	11	11	12	12	13	18	27	93	24	39	32
VLADIMIR	16	18	24	22	23	8	9	9	10	11	12	11	18	26	98	23	37	31
IVANOVO	16	19	25	23	24	9	10	9	10	11	12	11	19	28	93	23	37	32
KALININ	18	18	24	22	22	12	13	12	10	11	15	14	16	26	96	25	40	31
KALUGA	18	17	22	20	21	12	13	11	9	10	16	13	14	25	96	24	38	30
KOSTROMA	15	20	25	23	24	10	11	11	12	13	11	13	20	28	92	24	39	33
RYAZAN	18	14	20	18	20	10	11	9	9	10	14	11	17	23	94	22	36	28
TULA	18	15	21	19	20	12	13	10	7	8	16	12	15	23	96	23	37	29
KAZAN	16	19	21	19	20	2	4	5	7	8	7	7	24	23	86	18	33	28
GORKIY	14	20	22	20	21	6	7	8	8	9	10	10	20	25	90	21	36	30
KIROV	8	25	27	25	25	9	10	13	13	14	5	15	25	29	86	25	40	34
YOSHKAR_OLA	18	20	21	19	20	4	5	6	8	9	8	8	24	24	87	19	34	29
SARANSK	17	17	19	17	18	7	8	5	5	6	11	7	21	21	90	18	32	26
CHEBOKSARY	17	19	21	19	20	4	5	6	7	8	8	8	22	24	87	19	33	29
ULYANOVSK	19	16	18	16	17	3	4	3	5	6	10	5	24	21	87	20	35	26
BELGOROD	23	10	16	14	16	16	17	14	10	11	23	16	12	19	99	25	40	24
VORONEZH	22	10	16	14	16	13	13	10	6	7	19	12	15	19	96	21	36	24
KURSK	21	12	18	16	17	15	15	12	9	10	19	14	12	21	98	24	39	26
OREL	20	13	20	18	19	14	15	12	8	9	18	14	13	22	98	23	38	27
BRYANSK	20	14	20	18	19	14	15	13	10	10	18	15	12	23	98	25	39	28
LIPETSK	21	12	18	16	17	12	12	9	6	7	18	11	16	20	95	21	35	25
TAMBOV	21	13	18	16	18	10	10	7	4	5	16	9	17	22	94	19	34	27
PENZA	19	15	19	17	18	7	7	4	4	5	13	6	21	22	90	17	32	27
ASTRAKHAN	29	11	7	5	6	13	13	10	7	8	18	12	25	9	97	20	33	14
VOLGOGRAD	26	7	11	9	10	10	10	9	4	3	15	11	20	14	95	19	34	19
KUYBYSHEV	22	16	18	16	17	3	3	1	4	5	7	2	24	21	86	18	28	26
SARATOV	22	12	14	12	12	7	7	4	1	1	11	6	21	16	90	15	30	21
ROSTOV	28	4	9	6	8	17	17	14	12	9	20	16	17	13	100	25	39	18
KRASNODAR	32	1	9	7	8	18	19	16	12	10	22	18	21	12	102	27	38	17
STAVROPOL	32	3	9	6	8	18	19	16	12	11	23	18	21	12	102	27	38	17
MAKHACHKALA	34	8	4	2	1	19	20	17	13	13	23	19	26	4	103	26	30	9
NALCHIK	35	5	4	2	4	19	20	18	13	13	24	20	23	7	104	27	34	12
ORDZHONIKIDZE	35	6	3	1	3	19	20	17	13	14	24	19	24	7	103	26	30	12
GROZNYY	34	7	2	1	2	18	19	16	12	12	23	18	25	5	102	25	28	10
KIEV	25	13	19	17	18	19	20	17	14	15	22	19	7	22	103	29	43	27

DISTANCES TO 1960 OIL SOURCES IN 100 KM

NODE	KOMI	KRASNODR	STAVROPL	GROZNYY	DAGESTAN	TATAR	BASHKIR	KUBYSHEV	SARATOV	VOLGOGRD	PERM	ORENBURG	W_UKRAIN	BAKU	SAKHALIN	EMBA60	FERGANA	TURKMEN
ZAPOROZHYE	27	9	15	13	14	19	20	17	13	12	24	19	13	18	103	28	43	23
KHARKOV	24	10	16	14	15	16	16	13	10	11	21	15	12	19	100	25	40	24
LVOV	29	19	25	23	24	24	25	23	19	20	27	25	1	28	107	34	49	33
KISHINEV	31	16	22	20	21	25	26	23	19	19	29	25	6	25	109	34	49	30
TALLIN	21	25	31	29	31	20	21	21	19	20	21	23	17	35	102	34	48	40
RIGA	23	23	29	27	28	19	20	20	17	18	22	22	13	32	103	33	47	37
VILNIUS	24	20	26	24	26	20	21	20	17	18	23	22	9	29	103	32	47	34
KALININGRAD	27	23	29	27	29	23	24	23	20	21	26	25	13	32	107	35	50	37
SMOLENSK	20	17	23	21	22	14	15	14	11	12	18	16	11	26	98	26	41	31
PSKOV	20	22	28	26	28	17	18	17	15	16	19	19	14	32	100	30	45	37
MINSK	23	18	24	22	23	17	18	18	15	16	21	20	9	27	101	30	45	32
TBILISI	40	11	13	11	9	26	27	24	20	18	30	26	28	5	110	35	28	10
BAKU	38	12	7	5	4	23	24	21	16	17	27	23	30	1	107	29	23	5
YEREVAN	43	14	14	12	10	29	30	27	23	22	34	29	32	7	113	31	30	12
LUTSK	28	18	24	22	23	23	24	21	18	19	26	23	3	27	107	33	48	32
ROVNO	27	17	23	21	22	22	23	20	17	18	25	22	3	26	106	32	47	31
UZHGOROD	31	20	26	24	25	25	26	24	21	22	29	26	2	29	110	36	50	34
IVANO_FRANKOVSK	30	20	26	24	25	24	25	24	20	21	28	26	1	29	109	35	50	33
TERNOPOL	28	18	24	22	23	23	24	22	18	19	26	24	2	27	107	33	48	32
ZHITOMIR	26	15	21	19	20	20	21	19	15	16	24	21	6	24	104	30	45	28
VINNITSA	27	15	21	19	21	21	22	19	16	17	25	21	5	24	105	31	45	29
KHMELNITSKIY	28	17	23	21	22	22	23	21	17	18	26	23	3	26	106	32	47	30
CHERNOVSTY	31	19	25	23	24	24	25	23	20	21	28	25	2	28	109	35	49	35
CHERNIGOV	23	13	19	17	18	18	19	17	13	14	21	19	8	23	101	28	43	27
SUMY	23	12	18	16	17	17	18	15	11	12	21	17	11	20	101	26	41	24
POLTAVA	25	10	16	14	15	18	18	15	11	12	22	17	11	19	103	26	41	23
CHERKASSY	26	12	18	16	18	20	21	18	15	16	23	20	9	21	104	30	44	26
KIROVOGRAD	27	13	19	17	18	21	21	18	15	16	24	20	8	22	104	30	45	26
ODESSA	29	10	20	18	18	24	24	21	17	18	27	23	8	22	107	33	48	26
NIKOLAYEV	29	7	16	14	15	22	22	19	16	15	27	21	11	19	105	31	45	23
KHERSON	29	7	15	13	14	22	22	19	15	15	27	21	11	18	105	30	45	23
SIMFEROPOL	31	6	14	14	13	23	23	20	17	16	27	22	14	17	106	32	46	22
DNEPROPETROVSK	26	8	15	13	14	19	19	16	12	12	24	18	12	18	102	27	42	22
DONETSK	27	6	11	9	10	17	18	15	11	10	22	17	15	15	101	26	41	20
VOROSHILOVGRAD	27	8	13	11	11	16	17	14	9	8	20	16	16	16	100	24	41	20
GRODNO	26	21	27	25	26	21	22	21	18	19	25	23	9	30	105	33	48	35
VITEBSK	22	18	24	22	23	16	17	14	13	14	19	16	12	27	100	28	42	30
MOGILEV	20	17	23	21	22	16	17	15	12	13	20	17	9	26	100	27	43	29
GOMEL	22	17	21	19	20	17	18	16	12	13	20	18	8	24	100	27	42	29
BREST	27	22	26	24	26	21	22	21	18	19	25	23	5	28	105	33	47	32
UFA	25	21	23	21	22	3	2	5	8	9	7	7	28	26	81	13	32	31
IZHEVSK	13	22	24	22	23	4	5	8	11	12	4	10	27	27	83	22	37	32
ORENBURG	26	19	20	18	18	7	6	4	8	9	14	2	29	22	85	9	24	27

DISTANCES TO 1960 OIL SOURCES IN 100 KM

NODE	KOMI	KRASNODR	STAVROPL	GROZNYY	DAGESTAN	TATAR	BASHKIR	KUBYSHEV	SARATOV	VOLGOGRD	PERM	ORENBURG	W_UKRAIN	BAKU	SAKHALIN	EMBA60	FERGANA	TURKMEN
PERM	14	26	28	26	27	4	5	7	11	12	1	9	29	30	81	19	34	35
SVERDLUVSK	18	27	29	27	28	9	8	11	14	15	4	13	32	32	77	15	30	37
CHELYABINSK	20	26	28	26	27	8	6	9	12	13	6	10	33	31	76	13	28	36
TYUMEN	21	31	33	31	31	12	11	14	17	18	7	16	36	35	74	18	33	40
KURGAN	21	29	30	28	29	10	8	11	14	15	7	13	36	33	74	156	30	38
OMSK	27	34	36	34	35	15	13	17	20	21	13	18	41	39	68	21	30	41
NOVOSIBIRSK	33	40	42	40	41	21	20	24	27	28	19	25	48	45	62	27	32	44
TOMSK	36	43	45	43	44	24	23	26	29	30	22	27	51	48	60	30	35	46
BARNAUL	36	43	45	43	44	24	23	26	29	30	22	28	50	47	65	30	30	42
KRASNOYARSK	40	48	50	48	49	29	28	31	34	35	27	32	55	53	54	35	39	51
IRKUTSK	51	59	61	59	60	40	39	42	45	46	38	43	66	63	43	47	49	61
CHITA	61	69	71	69	70	50	49	52	55	56	48	53	76	74	33	56	60	72
ABAKAN	41	49	51	49	49	30	29	32	35	36	27	33	56	52	61	36	36	48
KEMEROVO	36	43	45	43	44	24	23	26	29	30	22	27	51	48	62	30	34	45
ULAN_UDE	56	63	65	63	64	44	43	46	49	50	42	48	71	68	39	50	54	66
VLADIVOSTOK	93	100	102	100	101	81	80	83	86	87	79	85	108	105	18	87	91	103
KHABAROVSK	85	92	94	92	93	73	72	75	78	79	71	76	99	97	10	79	83	95
BLAGOVESHCHENSK	79	87	89	87	88	68	67	70	73	74	65	71	94	91	18	74	78	89
YUZHNO_SAKHALINSK	96	103	105	103	104	85	84	87	90	91	82	88	111	108	14	90	94	106
MAGADAN	100	108	110	108	108	89	88	91	94	95	86	92	115	112	8	94	99	110
YAKUTSK	83	91	93	91	92	72	71	74	77	78	69	75	98	95	33	78	82	93
PETROPAVLOVSK_KAM	113	110	112	110	111	91	90	93	96	97	89	94	118	115	10	97	101	113
GURYEV	35	27	27	25	26	15	14	17	15	16	19	11	36	29	89	1	26	34
AKTYUBINSK	29	22	22	20	20	9	8	11	10	11	14	5	31	24	84	6	22	29
URALSK	26	16	16	14	15	9	8	8	4	5	16	5	25	19	88	11	25	24
KUSTANAY	23	28	28	26	27	10	9	12	15	16	9	10	37	31	77	13	27	36
PETROPAVLOVSK	24	31	33	31	32	12	11	14	17	18	10	16	40	36	71	18	27	39
KOKCHETAV	26	33	32	30	31	14	13	16	19	20	12	14	41	35	73	17	25	37
TSELINOGRAD	29	33	34	32	32	17	16	18	21	22	15	16	43	36	73	18	22	34
KARAGANDA	31	36	36	34	35	19	18	21	24	25	17	18	45	36	75	21	20	31
KZYL_ORDA	39	31	31	29	30	18	17	20	19	20	23	16	40	27	90	16	10	22
CHIMKENT	43	36	31	29	35	23	22	25	24	28	25	20	45	24	86	20	7	19
DZHAMBUL	46	38	33	31	37	25	24	27	26	27	30	23	47	26	83	23	9	21
SEMIPALATINSK	39	47	48	46	45	28	27	30	33	34	25	29	56	41	68	32	25	37
PAVLODAR	33	38	43	41	37	22	21	23	26	27	19	20	47	46	68	23	29	41
UST_KAMENOGORSK	40	39	49	47	48	29	28	31	34	35	26	30	48	45	69	24	29	40
ALMA_ATA	42	43	39	37	35	31	30	30	33	33	28	27	53	31	79	27	15	27
ASHKHABAD	44	20	16	14	12	37	36	26	22	23	33	28	38	9	101	33	18	4
DUSHANBE	57	34	30	28	27	37	36	36	36	37	42	33	52	23	101	33	15	18
TASHKENT	44	33	29	27	25	25	24	23	25	26	29	20	46	21	88	21	5	17
FRUNZE	42	40	36	34	32	28	27	27	29	30	28	24	50	29	84	24	12	24
ELISTA	34	5	11	9	11	21	22	19	14	13	25	21	23	14	105	29	41	19

DISTANCES TO 1970 OIL SOURCES IN 100 KM

NODE	KOMI	KRASNODR	STAVROPL	GROZNYY	DAGESTAN	TATAR	BASHKIR	KUBYSHEV	SARATOV	VOLGOGRD	PERM	ORENBURG	UDMURT	RECHITSA	W_UKRAIN	E_UKRAIN	BAKU	SHAIM70	SAMTLR70	SAKHALIN	EMBA7075	UZEN7075	FERGANA	TURKMEN
LENINGRAD	17	23	29	27	28	17	18	17	15	16	17	19	19	9	16	14	31	28	33	98	27	35	45	36
MURMANSK	20	33	39	37	38	28	29	28	26	27	23	30	28	21	28	26	42	34	39	104	35	45	56	47
PETROZAVODSK	19	24	30	28	29	19	20	19	17	18	19	21	20	13	20	18	33	30	35	100	28	36	47	38
NOVGOROD	18	21	27	25	26	16	17	16	14	15	18	18	17	9	16	13	30	29	34	98	25	33	44	35
VOLOGDA	9	21	27	25	26	12	13	14	14	15	11	16	15	11	20	14	30	25	27	92	27	35	41	35
ARKHANGELSK	13	27	32	30	32	19	20	20	20	21	16	22	21	18	26	20	36	28	33	97	31	39	48	41
SYKTYVKAR	4	30	34	32	37	17	18	20	20	21	12	22	12	20	29	23	36	23	28	93	31	39	47	41
MOSCOW	16	16	22	20	21	10	11	11	9	10	14	13	12	6	16	9	25	24	29	95	20	28	38	30
YAROSLAVL	13	19	25	23	24	10	12	11	11	12	12	13	12	9	18	12	27	23	28	93	22	30	39	32
VLADIMIR	16	18	24	22	23	8	9	9	10	11	12	11	11	8	18	11	26	23	28	98	21	29	37	31
IVANOVO	16	19	25	23	24	9	10	9	10	11	12	11	11	10	19	12	28	23	28	93	21	29	37	32
KALININ	18	18	24	22	22	12	13	12	10	11	15	14	14	8	15	10	26	26	31	96	21	29	40	31
KALUGA	18	17	22	20	21	12	13	11	9	10	16	13	14	5	14	8	25	26	31	96	20	28	38	30
KOSTROMA	15	20	25	23	24	10	11	11	12	13	11	13	11	11	20	13	28	22	27	92	23	31	39	33
RYAZAN	18	14	20	18	20	10	11	9	9	10	14	11	12	9	17	9	23	25	30	94	15	26	36	28
TULA	18	15	21	19	20	12	13	10	7	8	16	12	14	6	15	7	23	26	31	96	18	26	37	29
KAZAN	16	19	21	19	20	2	4	5	7	8	7	7	4	15	24	17	23	16	21	86	18	26	33	28
GORKIY	14	20	22	20	21	6	7	8	8	9	10	10	9	11	20	13	25	21	25	90	19	27	36	30
KIROV	8	25	27	25	25	9	10	13	13	14	5	15	5	15	25	18	29	16	21	86	24	32	40	34
YOSHKAR_OLA	18	20	21	19	20	4	5	6	8	9	8	8	5	15	24	18	24	18	22	87	19	27	34	29
SARANSK	17	17	19	17	18	7	8	5	5	6	11	7	8	13	21	12	21	20	25	90	15	24	32	26
CHEBOKSARY	17	19	21	19	20	4	5	6	7	8	8	8	5	13	22	15	24	18	22	87	16	24	33	29
ULYANOVSK	19	16	18	16	17	3	4	3	5	6	10	5	6	15	24	14	21	19	24	87	15	23	35	26
BELGOROD	23	10	16	14	16	16	17	14	10	11	23	16	19	5	12	2	19	32	36	99	17	25	40	24
VORONEZH	22	10	16	14	16	13	13	10	6	7	19	12	15	7	15	5	19	29	33	96	15	23	36	24
KURSK	21	12	18	16	17	15	15	12	9	10	19	14	17	5	12	3	21	30	35	98	17	25	39	26
OREL	20	13	20	18	19	14	15	12	8	9	18	14	16	4	13	5	22	28	33	98	18	26	38	27
BRYANSK	20	14	20	18	19	14	15	13	10	10	18	15	15	3	12	5	23	28	33	98	19	27	39	28
LIPETSK	21	12	18	16	17	12	12	9	6	7	18	11	15	7	16	6	20	27	32	95	15	23	35	25
TAMBOV	21	13	18	16	18	10	10	7	4	5	16	9	13	9	17	8	22	25	30	94	15	23	34	27
PENZA	19	15	19	17	18	7	7	4	4	5	13	6	9	12	21	10	22	22	27	90	14	22	32	27
ASTRAKHAN	29	11	7	5	6	13	13	10	7	8	18	12	18	18	25	14	9	25	30	92	4	11	29	14
VOLGOGRAD	26	7	11	9	10	10	10	9	4	3	15	11	15	13	20	10	14	27	32	95	9	16	34	19
KUYBYSHEV	22	16	18	16	17	3	3	1	4	5	7	2	9	16	24	15	21	19	24	86	10	18	28	26
SARATOV	22	12	14	12	12	7	7	4	1	1	11	6	11	12	21	12	16	23	28	90	11	19	30	21
ROSTOV	28	4	9	6	8	17	17	14	12	9	20	16	20	11	17	7	13	33	38	100	14	22	39	18
KRASNODAR	32	1	9	7	9	18	19	16	12	10	22	18	22	17	21	11	12	35	40	102	15	23	38	17
STAVROPOL	32	3	9	6	8	18	19	16	12	11	23	18	23	17	21	11	12	35	40	102	15	23	38	17
MAKHACHKALA	34	8	4	2	1	19	20	17	13	13	23	19	23	20	26	16	4	32	37	103	10	18	30	9
NALCHIK	35	5	4	2	4	19	20	18	13	13	24	20	24	18	23	14	7	33	38	104	11	19	34	12
ORDZHONIKIDZE	35	5	3	1	3	19	20	17	13	14	24	19	24	19	24	14	7	32	37	103	10	18	30	12
GROZNYY	34	7	2	1	2	18	19	16	12	12	23	18	22	19	25	15	5	31	36	102	9	17	28	10
KIEV	25	13	19	17	18	19	20	17	14	15	22	19	20	3	7	2	22	33	38	103	21	29	43	27

DISTANCES TO 1970 OIL SOURCES IN 100 KM

NODE	KOMI	KRASNODR	STAVROPL	GROZNYY	DAGESTAN	TATAR	BASHKIR	KUBYSHEV	SARATOV	VOLGOGRD	PERM	ORENBURG	UDMURT	RECHITSA	W_UKRAIN	E_UKRAIN	BAKU	SHAIM70	SAMTLR70	SAKHALIN	EMBA7075	UZEN7075	FERGANA	TURKMEN
ZAPOROZHYE	27	9	15	13	14	19	20	17	13	12	24	19	23	9	13	4	18	35	40	103	18	26	43	23
KHARKOV	24	10	16	14	15	16	16	13	10	11	21	15	19	6	12	2	19	31	36	100	17	25	40	24
LVOV	29	19	25	23	24	24	25	23	19	20	27	25	25	7	1	9	28	38	43	107	27	35	49	33
KISHINEV	31	16	22	20	21	25	26	23	19	19	29	25	27	10	6	8	25	39	44	109	25	35	49	30
TALLIN	21	25	31	29	31	20	21	21	19	20	21	23	22	12	17	16	35	32	37	102	33	38	48	40
RIGA	23	23	29	27	28	19	20	20	17	18	22	22	21	8	13	14	32	33	38	103	28	36	47	37
VILNIUS	24	20	26	24	26	20	21	20	17	18	23	22	21	5	9	13	29	34	39	103	27	35	47	34
KALININGRAD	27	23	29	27	29	23	24	23	20	21	26	25	25	8	13	13	32	37	42	107	30	38	50	37
SMOLENSK	20	17	23	21	22	14	15	14	11	12	18	16	16	4	11	9	26	28	33	98	22	30	41	31
PSKOV	20	22	28	26	28	17	18	17	15	16	19	19	19	8	14	13	32	30	35	100	27	35	45	37
MINSK	23	18	24	22	23	17	18	18	15	16	21	20	19	3	9	8	27	32	37	101	25	33	45	32
TBILISI	40	11	13	11	9	26	27	24	20	18	30	26	30	23	28	19	5	41	46	110	19	27	28	10
BAKU	38	12	7	5	4	23	24	21	16	17	27	23	27	24	30	20	1	35	40	107	13	21	23	5
YEREVAN	43	14	14	12	10	29	30	27	23	22	34	29	34	27	32	22	7	42	47	113	20	28	30	12
LUTSK	28	18	24	22	23	23	24	21	18	19	26	23	24	6	3	8	27	36	41	107	26	34	48	32
ROVNO	27	17	23	21	22	22	23	20	17	18	25	22	23	5	3	7	26	36	40	106	25	33	47	31
UZHGOROD	31	20	26	24	25	25	26	24	21	22	29	26	26	9	2	10	29	40	45	110	28	36	50	34
IVANO_FRANKOVSK	30	20	26	24	25	24	25	24	20	21	28	26	27	8	1	9	29	39	44	109	28	36	50	33
TERNOPOL	28	18	24	22	23	23	24	22	18	19	26	24	24	6	2	9	27	37	41	107	26	34	48	32
ZHITOMIR	26	15	21	19	20	20	21	19	15	16	24	21	22	4	6	5	24	35	39	104	24	31	45	28
VINNITSA	27	15	21	19	21	21	22	19	16	17	25	21	22	5	5	5	24	35	40	105	24	32	45	29
KHMELNITSKIY	28	17	23	21	22	22	23	21	17	18	26	23	24	6	3	7	26	36	41	106	25	33	47	30
CHERNOVSTY	31	19	25	23	24	24	25	23	20	21	28	25	26	9	2	11	28	39	44	109	28	35	49	35
CHERNIGOV	23	13	19	17	18	18	19	17	13	14	21	19	19	1	8	2	23	32	37	101	22	30	43	27
SUMY	23	12	18	16	17	17	18	15	11	12	21	17	19	4	11	1	20	31	36	101	19	27	41	24
POLTAVA	25	10	16	14	15	18	18	15	11	12	22	17	21	5	11	1	19	33	38	103	18	26	41	23
CHERKASSY	26	12	18	16	18	20	21	18	15	16	23	20	21	5	9	2	21	34	39	104	21	29	44	26
KIROVOGRAD	27	13	19	17	18	21	21	18	15	16	24	20	22	6	8	3	22	35	40	104	21	29	45	26
ODESSA	29	10	20	18	18	24	24	21	17	18	27	23	25	8	8	6	22	38	43	107	24	32	48	26
NIKOLAYEV	29	7	16	14	15	22	22	19	16	15	27	21	25	8	11	4	19	37	42	105	21	29	45	23
KHERSON	29	7	15	13	14	22	22	19	15	15	27	21	25	8	11	4	18	37	42	105	21	29	45	23
SIMFEROPOL	31	6	14	14	13	23	23	20	17	16	27	22	26	12	14	7	17	38	43	106	21	29	46	22
DNEPROPETROVSK	26	8	15	13	14	19	19	16	12	12	24	18	22	7	12	3	18	34	39	102	18	26	42	22
DONETSK	27	6	11	9	10	17	18	15	11	10	22	17	20	9	15	5	15	33	37	101	15	23	41	20
VOROSHILOVGRAD	27	4	13	11	11	16	17	14	9	8	20	16	19	9	16	6	16	32	37	100	14	22	41	20
GRODNO	26	21	27	25	26	21	22	21	18	19	25	23	23	6	9	11	30	35	40	105	28	35	48	35
VITEBSK	22	18	24	22	23	16	17	14	13	14	19	16	17	4	12	8	27	30	35	100	23	31	42	30
MOGILEV	20	17	23	21	22	16	17	15	12	13	20	17	18	2	9	7	26	30	35	100	22	30	43	29
GOMEL	22	17	21	19	20	17	18	16	12	13	20	18	18	1	5	5	24	31	36	100	22	30	42	29
BREST	27	22	26	24	26	21	22	21	18	19	25	23	23	5	5	9	28	35	40	105	27	35	47	32
UFA	25	21	23	21	22	3	2	5	8	9	7	7	10	21	28	20	26	13	18	81	13	19	32	31
IZHEVSK	13	22	24	22	23	4	5	8	11	12	4	10	1	19	27	21	27	13	18	83	21	29	37	32
ORENBURG	26	19	20	18	18	7	6	4	8	9	14	2	17	20	29	20	22	18	23	85	9	17	24	27

DISTANCES TO 1970 OIL SOURCES IN 100 KM

NODE	KOMI	KRASNODR	STAVROPL	GROZNYY	DAGESTAN	TATAR	BASHKIR	KUBYSHEV	SARATOV	VOLGOGRD	PERM	ORENBURG	UDMURT	RECHITSA	W UKRAIN	E UKRAIN	BAKU	SHAIM70	SAMTLR70	SAKHALIN	EMBA7075	UZEN7075	FERGANA	TURKMEN
PERM	14	26	28	25	27	4	5	7	11	12	1	9	5	20	29	23	30	11	16	81	19	27	34	35
SVERDLOVSK	18	27	29	27	28	5	8	11	14	15	4	13	5	23	32	27	32	7	12	77	15	23	30	37
CHELYABINSK	20	26	28	26	27	8	6	9	12	13	6	10	8	26	33	25	31	9	14	76	13	21	28	36
TYUMEN	21	31	33	31	31	12	11	14	17	15	7	16	8	27	36	30	35	4	9	74	18	26	33	40
KURGAN	21	29	30	28	29	10	8	11	14	15	7	13	9	27	36	32	33	9	14	74	16	24	30	38
OMSK	27	34	36	34	35	15	13	17	20	21	13	18	14	32	41	36	39	10	12	68	21	29	30	41
NOVOSIBIRSK	33	40	42	40	41	21	20	24	27	28	19	25	20	39	48	42	45	16	18	62	27	36	32	44
TOMSK	36	43	45	43	44	24	23	26	29	30	22	27	23	42	51	45	48	19	21	60	30	38	35	46
BARNAUL	36	43	45	43	44	24	23	26	29	30	22	28	23	42	50	45	47	19	21	65	30	38	30	42
KRASNOYARSK	40	48	50	48	49	29	28	31	34	35	27	32	28	46	55	50	53	24	26	54	35	43	39	51
IRKUTSK	51	59	61	59	60	40	39	42	45	46	38	43	39	57	66	61	63	35	37	43	47	55	49	61
CHITA	61	69	71	69	70	50	49	52	55	56	48	53	49	67	76	71	74	45	47	33	56	54	60	72
ABAKAN	41	49	51	49	49	30	29	32	35	36	27	33	29	47	56	51	52	24	27	61	36	44	35	48
KEMEROVO	36	43	45	43	44	24	23	26	29	30	22	27	23	42	51	45	48	19	21	62	30	38	34	45
ULAN_UDE	56	63	65	63	64	44	43	46	49	50	42	48	43	62	71	65	68	39	41	39	50	58	54	66
VLADIVOSTOK	93	100	102	100	101	81	80	83	86	87	79	85	80	99	108	103	105	76	78	18	87	95	91	103
KHABAROVSK	85	92	94	92	93	73	72	75	78	79	71	76	72	90	99	94	97	68	70	10	79	87	83	95
BLAGOVESHCHENSK	79	87	89	87	88	68	67	70	73	74	65	71	67	85	94	89	91	62	65	18	74	82	78	89
YUZHNO_SAKHALINSK	96	103	105	103	104	85	84	87	90	91	82	88	84	102	111	105	100	79	81	14	90	98	94	106
MAGADAN	100	108	110	108	108	89	88	91	94	95	86	92	88	106	115	110	112	83	86	8	94	102	99	110
YAKUTSK	83	91	93	91	92	72	71	74	77	78	69	75	71	89	98	93	95	66	71	33	78	86	82	93
PETROPAVLOVSK_KAM	113	110	112	110	111	91	90	93	96	97	89	94	90	108	118	112	115	93	88	10	97	105	101	113
GURYEV	33	14	10	8	9	15	14	13	10	11	19	11	21	21	29	17	12	22	27	89	1	8	26	17
AKTYUBINSK	29	20	16	14	15	9	8	11	10	11	14	5	16	22	31	22	18	17	22	84	6	12	22	23
URALSK	26	16	16	14	15	9	8	8	4	5	14	5	14	17	25	17	19	21	26	88	11	17	25	24
KUSTANAY	23	28	28	26	27	10	9	12	15	16	9	10	11	28	37	28	31	12	17	77	13	21	27	36
PETROPAVLOVSK	24	31	33	31	32	12	11	14	17	18	10	16	11	30	40	31	36	12	15	71	18	25	27	39
KOKCHETAV	26	33	32	30	31	14	13	16	19	20	12	14	13	32	41	33	35	14	17	73	17	25	25	37
TSELINOGRAD	29	33	34	32	32	17	16	18	21	22	15	16	17	34	43	34	36	17	20	73	18	26	22	34
KARAGANDA	31	36	36	34	35	19	18	21	24	25	17	18	20	36	45	37	36	19	22	75	21	29	20	31
KZYL_ORDA	39	31	31	29	30	18	17	20	19	20	25	16	25	32	40	31	27	27	31	90	16	20	10	22
CHIMKENT	43	36	31	29	35	23	22	25	24	28	25	20	30	36	45	36	24	31	34	86	20	23	7	19
DZHAMBUL	46	38	33	31	37	25	24	27	26	27	30	23	32	38	47	38	26	34	32	83	23	27	9	21
SEMIPALATINSK	39	47	48	46	45	28	27	30	33	34	25	29	27	45	56	47	41	22	24	68	32	32	25	37
PAVLODAR	33	38	43	41	37	22	21	23	26	27	19	20	21	38	47	38	46	16	19	68	23	23	29	41
UST_KAMENOGORSK	40	39	49	47	48	29	28	31	34	35	26	30	28	42	49	40	45	24	26	69	24	24	29	40
ALMA_ATA	42	43	39	37	35	31	30	30	33	33	28	27	30	44	53	44	31	30	33	79	27	27	15	27
ASHKHABAD	44	20	16	14	12	37	36	26	22	23	33	28	33	33	38	28	9	45	49	101	20	20	18	4
DUSHANBE	57	34	30	28	27	37	36	36	36	37	42	33	45	47	52	43	23	45	50	101	23	23	15	18
TASHKENT	44	33	29	27	25	25	24	23	25	26	29	20	32	37	46	37	21	32	37	88	21	21	5	17
FRUNZE	42	40	36	34	32	28	27	27	29	30	28	24	29	41	50	41	29	30	33	84	24	24	12	24
ELISTA	34	5	11	9	11	21	22	19	14	13	25	21	25	20	23	14	14	37	42	105	18	26	41	19

DISTANCES TO 1975 OIL SOURCES IN 100 KM

NODE	KOMI	KRASNODR	STAVROPL	GROZNYY	DAGESTAN	TATAR	BASHKIR	KUBYSHEV	SARATOV	VOLGOGRD	PERM	ORENBURG	UDMURT	RECHITSA	W_UKRAIN	E_UKRAIN	BAKU	SHAIM75	SAMTLR75	SAKHALIN	EMBA7075	UZEN7075	FERGANA	TURKMEN
LENINGRAD	17	23	29	27	28	17	18	17	15	16	17	19	19	9	16	14	31	28	33	98	27	35	45	36
MURMANSK	20	33	39	37	28	28	29	28	26	27	23	30	28	21	28	26	42	34	39	104	35	45	56	47
PETROZAVODSK	19	24	30	28	29	19	20	19	17	18	19	21	20	13	20	18	33	30	35	100	28	36	47	38
NOVGOROD	18	21	27	25	26	16	17	16	14	15	18	18	17	9	16	13	30	29	35	93	25	33	44	35
VOLOGDA	9	21	27	25	26	12	13	14	14	15	11	16	15	11	20	14	30	25	27	92	27	35	41	35
ARKHANGELSK	13	27	32	30	32	19	20	20	20	21	16	22	21	19	25	20	36	29	33	97	31	39	48	41
SYKTYVKAR	4	30	34	32	32	17	18	20	20	21	12	22	12	20	29	23	36	23	28	93	31	39	47	41
MOSCOW	16	16	22	20	21	10	11	11	9	10	14	13	12	6	16	9	25	24	29	95	20	28	38	30
YAROSLAVL	13	19	25	23	24	10	12	11	11	12	12	13	12	9	18	12	27	23	28	93	22	30	39	32
VLADIMIR	16	18	24	22	23	8	9	9	10	11	12	11	11	9	18	11	26	23	28	90	21	29	37	31
IVANOVO	16	19	25	23	24	9	10	9	10	11	12	11	11	10	19	12	28	23	28	93	21	29	37	32
KALININ	18	18	24	22	22	12	13	12	10	11	15	14	14	8	16	10	26	26	31	96	21	29	40	31
KALUGA	19	17	22	20	21	12	13	11	9	10	16	13	14	5	14	8	25	26	31	96	20	28	38	30
KOSTROMA	15	20	25	23	24	10	11	11	12	13	11	13	11	11	20	13	28	22	27	92	23	31	39	33
RYAZAN	18	14	20	19	20	10	11	9	9	10	14	11	12	9	17	9	23	25	30	94	18	26	36	28
TULA	18	15	21	19	20	12	13	10	7	8	16	12	14	6	15	7	23	26	31	96	18	26	37	29
KAZAN	16	19	21	19	20	2	4	5	7	8	7	7	4	15	24	17	23	16	21	86	18	26	33	28
GORKIY	14	20	22	20	21	6	7	8	8	9	10	10	9	11	20	13	25	21	25	90	19	27	36	30
KIROV	8	25	27	25	25	9	10	13	13	14	5	15	5	15	25	18	29	16	21	86	24	32	40	34
YOSHKAR_OLA	18	20	21	19	20	4	5	6	8	9	8	8	5	15	24	18	24	18	22	87	19	27	34	29
SARANSK	17	17	19	17	19	7	8	5	5	6	11	7	8	13	21	12	21	20	25	90	16	24	32	26
CHEBOKSARY	17	19	21	19	20	4	5	6	7	8	8	8	5	13	22	15	24	18	22	87	16	24	33	29
ULYANOVSK	19	16	18	16	17	3	4	3	5	6	10	5	6	15	24	14	21	19	24	87	15	23	35	26
BELGOROD	23	10	16	14	16	16	17	14	10	11	23	16	19	5	12	2	19	32	36	99	17	25	40	24
VORONEZH	22	10	16	14	16	13	13	10	6	7	19	12	15	7	15	5	19	29	33	96	15	23	36	24
KURSK	21	12	18	16	17	15	15	12	9	10	19	14	17	5	12	3	21	30	35	98	17	25	39	26
OREL	20	13	20	18	19	14	15	12	8	9	18	14	16	4	13	5	22	28	33	98	18	26	38	27
BRYANSK	20	14	20	18	19	14	15	13	10	10	18	15	15	3	12	5	23	28	33	98	19	27	39	29
LIPETSK	21	12	18	16	17	12	12	9	6	7	18	11	15	7	16	6	20	27	32	95	15	23	35	25
TAMBOV	21	13	18	16	18	10	10	7	4	5	16	9	13	9	17	8	22	25	30	94	15	23	34	27
PENZA	19	15	19	17	18	7	7	4	4	5	13	6	9	12	21	10	22	22	27	90	14	22	32	27
ASTRAKHAN	29	11	7	5	6	13	13	10	7	8	18	12	18	18	25	14	9	25	30	92	4	11	29	14
VOLGOGRAD	26	7	11	9	10	10	10	9	4	3	15	11	15	13	20	10	14	27	32	95	9	16	34	19
KUYBYSHEV	22	16	18	16	17	3	3	1	4	5	7	2	9	16	24	15	21	19	22	86	10	18	28	26
SARATOV	22	12	14	12	12	7	7	4	1	1	11	6	11	12	21	12	16	23	26	90	11	19	30	21
ROSTOV	28	4	9	6	9	17	17	14	12	9	20	16	20	11	17	7	13	33	38	100	14	22	39	18
KRASNODAR	32	1	9	7	8	18	19	16	12	10	22	18	22	17	21	11	12	35	40	102	15	23	38	17
STAVROPOL	32	3	9	6	8	18	19	16	12	11	23	18	23	17	21	11	12	35	40	102	15	23	38	17
MAKHACHKALA	34	8	4	2	1	19	20	17	13	13	23	19	23	20	26	16	4	32	37	103	10	18	30	9
NALCHIK	35	5	4	2	4	19	20	18	13	13	24	20	24	18	23	14	7	33	33	104	11	19	34	12
ORDZHONIKIDZE	35	6	3	1	3	19	20	17	13	14	24	19	24	19	24	14	7	32	37	103	10	18	30	12
GROZNYY	34	7	2	1	2	18	19	16	12	12	23	18	22	19	25	15	5	31	36	102	9	17	28	10
KIEV	25	13	19	17	18	19	20	17	14	15	22	19	20	3	7	2	22	33	38	103	21	29	43	27

DISTANCES TO 1975 OIL SOURCES IN 100 KM

NODE	KOMI	KRASNODR	STAVROPL	GROZNYY	DAGESTAN	TATAR	BASHKIR	KUBYSHEV	SARATOV	VOLGOGRD	PERM	ORENBURG	UDMURT	RECHITSA	W_UKRAIN	E_UKRAIN	BAKU	SHAIM75	SAMTLR75	SAKHALIN	EMBA7075	UZFNT075	FERGANA	TURKMEN
ZAPOROZHYE	27	9	15	13	14	19	20	17	13	12	24	19	23	9	13	4	18	35	40	103	18	26	43	23
KHARKOV	24	10	16	14	15	16	16	13	10	11	21	15	19	6	12	2	19	31	36	100	17	25	40	24
LVOV	29	19	25	23	24	24	25	23	19	20	27	25	25	7	1	9	28	38	43	107	27	35	49	33
KISHINEV	31	16	22	20	21	25	26	23	19	19	29	25	27	10	6	8	25	39	44	109	25	35	49	30
TALLIN	21	25	31	29	31	20	21	21	19	20	21	23	22	12	17	16	35	32	37	102	30	38	48	40
RIGA	23	23	29	27	28	19	20	20	17	18	22	22	21	8	13	14	32	33	38	103	28	36	47	37
VILNIUS	24	20	26	24	26	20	21	20	17	18	23	22	21	5	9	10	29	34	39	103	27	35	47	34
KALININGRAD	27	23	29	27	29	23	24	23	20	21	26	25	25	8	13	13	32	37	42	107	30	38	50	37
SMOLENSK	20	17	23	21	22	14	15	14	11	12	18	16	16	4	11	9	26	28	33	98	22	30	41	31
PSKOV	20	22	28	26	28	17	18	17	15	16	19	19	19	8	14	13	32	30	35	100	27	35	45	37
MINSK	23	18	24	22	23	17	18	18	15	16	21	20	19	3	9	8	27	32	37	101	25	33	45	32
TBILISI	40	11	13	11	9	26	27	24	20	18	30	26	30	23	28	19	5	41	46	110	19	27	28	10
BAKU	38	12	7	5	4	23	24	21	16	17	27	23	27	24	30	20	1	39	40	107	13	21	23	5
YEREVAN	43	14	14	12	10	29	30	27	23	22	34	29	34	27	32	22	7	42	47	113	20	28	30	12
LUTSK	28	18	24	22	23	23	24	21	18	19	26	23	24	6	3	8	27	36	41	107	26	34	48	32
ROVNO	27	17	23	21	22	22	23	20	17	18	25	22	23	5	3	7	26	36	40	106	25	33	47	31
UZHGOROD	31	20	26	24	25	25	26	24	21	22	29	26	26	9	2	10	29	40	45	110	28	36	50	34
IVANO_FRANKOVSK	30	20	26	24	25	24	25	24	20	21	28	26	27	8	1	9	29	39	44	109	28	36	50	33
TERNOPOL	28	18	24	22	23	23	24	22	18	19	26	24	24	6	2	9	27	37	41	107	26	34	48	32
ZHITOMIR	26	15	21	19	20	20	21	19	15	16	24	21	22	4	6	5	24	35	39	104	24	31	45	28
VINNITSA	27	15	21	19	21	21	22	19	16	17	25	21	22	5	5	5	24	35	40	105	24	32	45	29
KHMELNITSKIY	28	17	23	21	22	22	23	21	17	18	26	23	24	6	3	7	26	36	41	106	25	33	47	30
CHERNOVSTY	31	19	25	23	24	24	25	23	20	21	28	25	26	9	2	11	28	39	44	109	28	35	49	35
CHERNIGOV	23	13	19	17	18	18	19	17	13	14	21	19	19	1	8	2	23	32	37	101	22	30	43	27
SUMY	23	12	18	16	17	17	18	15	11	12	21	17	19	4	11	1	20	31	36	101	19	27	41	24
POLTAVA	25	10	16	14	15	18	18	15	11	12	22	17	21	5	11	1	19	33	38	103	18	26	41	23
CHERKASSY	26	12	18	16	18	20	21	18	15	16	23	20	21	5	9	2	21	34	39	104	21	29	44	26
KIROVOGRAD	27	13	19	17	18	21	21	18	15	16	24	20	22	6	8	3	22	35	40	104	21	29	45	25
ODESSA	29	10	20	18	18	24	24	21	17	18	27	23	25	8	6	6	22	38	43	107	24	32	48	26
NIKOLAYEV	29	7	16	14	15	22	22	19	16	15	27	21	25	8	11	4	19	37	42	105	21	29	45	23
KHERSON	29	7	15	13	14	22	22	19	15	15	27	21	25	8	11	4	18	37	42	105	21	29	45	23
SIMFEROPOL	31	6	14	14	13	23	23	20	17	16	27	22	26	12	14	7	17	38	43	106	21	29	46	22
DNEPROPETROVSK	26	8	15	13	14	19	19	16	12	12	24	18	22	7	12	3	18	34	39	102	18	26	42	22
DONETSK	27	6	11	9	10	17	18	15	11	10	22	17	20	9	15	5	15	33	37	101	15	23	41	20
VOROSHILOVGRAD	27	8	13	11	11	16	17	14	9	8	20	16	19	9	16	6	16	32	37	100	14	22	41	20
GRODNO	26	21	27	25	26	21	22	21	18	19	25	23	23	6	9	11	30	35	40	105	28	36	48	35
VITEBSK	22	18	24	22	23	16	17	14	13	14	19	16	17	4	12	8	27	30	35	100	23	31	42	30
MOGILEV	20	17	23	21	22	16	17	15	12	13	20	17	18	2	9	7	26	30	35	100	22	30	43	29
GOMEL	22	17	21	19	20	17	18	16	12	13	20	18	18	1	8	5	24	31	36	100	22	30	42	29
BREST	27	22	26	24	26	21	22	21	18	19	25	23	23	5	5	9	28	35	40	105	27	35	47	32
UFA	25	21	23	21	22	3	2	5	3	9	7	7	10	21	28	20	26	13	18	81	13	19	32	31
IZHEVSK	13	22	24	22	23	4	5	8	1	12	4	10	1	18	27	21	27	13	18	83	21	29	37	32
ORENBURG	26	19	20	18	18	7	6	4	8	9	14	2	12	20	29	20	22	18	23	85	9	17	24	27

DISTANCES TO 1975 OIL SOURCES IN 100 KM

NODE	KOMI	KRASNODR	STAVROPL	GROZNYY	DAGESTAN	TATAR	BASHKIR	KUBYSHEV	SARATOV	VOLGOGRD	PERM	ORENBURG	UDMURT	RECHITSA	W_UKRAIN	E_UKRAIN	BAKU	SHAIM75	SAMTLR75	SAKHALIN	EMBA7075	UZEN7075	FERGANA	TURKMEN
PERM	14	26	28	26	27	4	5	7	11	12	1	9	5	20	29	23	30	11	16	81	19	27	34	35
SVERDLOVSK	18	27	29	27	28	9	8	11	14	15	4	13	5	23	32	27	32	7	12	77	15	23	30	37
CHELYABINSK	20	26	28	26	27	8	6	9	12	13	6	10	8	26	33	25	31	9	14	76	13	21	28	36
TYUMEN	21	31	33	31	31	12	11	14	17	18	7	16	8	27	36	30	35	4	9	74	18	26	33	40
KURGAN	21	29	30	28	29	10	8	11	14	15	7	13	9	27	36	32	33	6	11	74	16	24	30	38
OMSK	27	34	36	34	35	15	13	17	20	21	13	18	14	32	41	36	39	10	12	68	21	29	30	41
NOVOSIBIRSK	33	40	42	40	41	21	20	24	27	28	19	25	20	39	48	42	45	16	10	62	27	36	32	44
TOMSK	36	43	45	43	44	24	23	26	29	30	22	27	23	42	51	45	48	19	7	60	30	38	35	46
BARNAUL	36	43	45	43	44	24	23	26	29	30	22	28	23	42	50	45	47	19	13	65	30	38	30	42
KRASNOYARSK	40	48	50	48	49	29	28	31	34	35	27	32	28	46	55	50	53	24	13	54	35	43	39	51
IRKUTSK	51	59	61	59	60	40	39	42	45	46	38	43	39	57	66	61	63	35	24	43	47	55	49	51
CHITA	61	69	71	69	70	50	49	52	55	56	48	53	49	67	76	71	74	45	34	33	56	54	60	72
ABAKAN	41	49	51	49	49	30	29	32	35	36	27	33	29	47	56	51	52	24	16	61	36	44	36	48
KEMEROVO	36	43	45	43	44	24	23	26	29	30	22	27	23	42	51	45	48	19	10	62	30	38	34	45
ULAN_UDE	56	63	65	63	64	44	43	46	49	50	42	48	43	62	71	65	68	39	28	39	50	58	54	66
VLADIVOSTOK	93	100	102	100	101	81	80	83	86	87	79	85	80	99	108	103	105	76	65	18	87	95	91	103
KHABAROVSK	85	92	94	92	93	73	72	75	78	79	71	76	72	90	99	94	97	68	57	10	79	87	83	95
BLAGOVESHCHENSK	79	87	89	87	88	68	67	70	73	74	65	71	67	85	94	89	91	62	51	18	74	82	78	89
YUZHNO_SAKHALINSK	96	103	105	103	104	85	84	87	90	91	82	88	84	102	111	105	108	79	69	14	90	98	94	106
MAGADAN	100	108	110	108	108	89	88	91	94	95	86	92	88	106	115	110	112	83	72	8	94	102	99	110
YAKUTSK	83	91	93	91	92	72	71	74	77	78	69	75	71	89	99	93	95	66	56	33	78	86	82	93
PETROPAVLOVSK_KAM	113	110	112	110	111	91	90	93	96	97	89	94	90	108	118	112	115	93	75	10	97	105	101	113
GURYEV	33	14	10	8	9	15	14	13	10	11	19	11	21	21	28	17	12	22	27	89	1	8	26	17
AKTYUBINSK	29	20	16	14	15	9	8	11	10	11	14	5	16	22	31	22	18	17	22	84	6	12	22	23
URALSK	26	16	16	14	15	9	8	8	4	5	16	5	14	17	25	17	19	21	26	88	11	17	25	24
KUSTANAY	23	28	28	26	27	10	9	12	15	16	9	10	11	28	37	28	31	11	17	77	13	21	27	36
PETROPAVLOVSK	24	31	33	31	32	12	11	14	17	18	10	16	11	30	40	31	36	9	14	71	18	26	27	39
KOKCHETAV	26	33	32	30	32	14	13	16	19	20	12	14	13	32	41	33	35	10	16	73	17	25	25	37
TSELINOGRAD	29	33	34	32	32	17	16	18	21	22	15	16	17	34	43	34	36	14	19	73	18	26	22	34
KARAGANDA	31	36	36	34	35	19	18	21	24	25	17	18	20	36	45	37	36	16	21	75	21	29	20	31
KZYL_ORDA	39	31	31	29	30	18	17	20	19	20	23	16	25	32	40	31	27	26	31	90	16	20	10	22
CHIMKENT	43	36	31	29	35	23	22	25	24	28	25	20	30	36	45	36	24	28	33	86	20	23	7	19
DZHAMBUL	46	38	33	31	37	25	24	27	26	27	30	23	32	38	47	38	26	26	31	83	23	27	9	21
SEMIPALATINSK	39	47	48	46	45	28	27	30	33	34	25	29	27	45	56	47	41	22	24	68	32	32	25	37
PAVLODAR	33	38	43	41	37	22	21	23	26	27	19	20	21	38	47	38	46	16	18	68	23	23	29	41
UST_KAMENOGORSK	40	39	49	47	48	29	28	31	34	35	26	30	29	42	48	40	45	24	26	69	24	24	29	40
ALMA_ATA	42	43	39	37	35	31	30	30	33	33	28	27	30	44	53	44	31	27	32	79	27	27	15	27
ASHKHABAD	44	20	16	14	12	37	35	26	22	23	33	28	33	33	38	28	9	42	38	101	20	20	18	4
DUSHANBE	57	34	30	28	27	37	36	36	36	37	42	33	45	47	52	43	23	43	48	101	23	23	15	18
TASHKENT	44	33	29	27	25	25	24	23	25	26	29	20	32	37	46	37	21	31	36	88	21	21	5	17
FRUNZE	42	40	36	34	32	28	27	27	29	30	28	24	29	41	50	41	29	27	32	84	24	24	12	24
ELISTA	34	5	11	9	11	21	22	19	14	13	25	21	25	20	23	14	14	37	42	105	18	26	41	19

APPENDIX C

DISTANCES TO GAS SOURCES

DISTANCES TO 1960 GAS SOURCES IN 100 KM

NODE	KRASNODR	STAVPOPL	GROZNYY	TATAR	BASHKIR	SARATOV	VOLGOGRD	DASHAVA	F_UKRAIN
LENINGRAD	18	20	24	28	30	15	17	21	16
NOVGOROD	16	18	22	26	29	13	15	19	14
MOSCOW	11	13	17	21	23	8	10	14	9
KALININ	13	15	19	24	26	10	12	16	11
KALUGA	12	14	18	23	25	10	12	13	8
RYAZAN	12	14	18	19	21	6	8	16	11
TULA	9	11	15	22	24	9	11	15	7
KAZAN	29	31	35	3	5	10	12	32	25
GORKIY	25	27	31	6	8	7	9	29	22
SARANSK	22	24	28	7	11	4	6	26	19
CHEBOKSARY	27	29	33	4	6	9	11	30	24
BELGOROD	9	11	16	29	31	16	18	15	2
VORONEZH	6	8	13	25	27	12	14	18	4
KURSK	11	13	17	28	30	15	18	14	4
OREL	13	15	19	26	28	14	17	12	5
BRYANSK	14	16	20	25	27	12	14	11	6
PEN[illegible]	21	23	27	10	12	2	4	25	18
VOLG[illegible]GRAD	22	24	28	16	18	4	2	26	19
SARATOV	18	20	24	13	15	1	2	22	15
ROSTOV	1	3	8	29	31	16	18	22	8
KRASNODAR	1	5	10	31	33	19	21	24	10
STAVROPOL	4	1	4	32	34	20	22	25	11
ORDZHONIKIDZE	9	4	2	36	38	24	26	27	13
GROZNYY	9	4	1	36	38	24	26	27	13
KIEV	19	21	25	30	32	17	19	6	12
KHARKOV	8	10	14	28	30	15	16	16	1
LVOV	24	26	30	36	38	23	25	1	18
TALLIN	21	23	27	31	33	18	20	24	19
MINSK	31	33	37	43	45	30	32	7	25
TERNOPOL	22	24	28	33	35	20	22	2	15
ZHITOMIR	21	23	27	32	34	19	21	5	13
VINNITSA	22	24.	28	33	35	20	22	5	14
DNEPROPETROVSK	10	12	16	29	31	17	18	18	2
VOROSHILOVGRAD	3	4	9	28	30	15	17	21	6
BREST	28	30	34	40	42	27	29	4	22
UFA	32	34	38	3	3	16	18	38	33

DISTANCES TO 1970 GAS SOURCES IN 100 KM

NODE	KOMI	KRASNODR	STAVROPL	GROZNYY	TATAR	BASHKIR	KUYBYSHV	SARATOV	VOLGOGRD	PERM	BAKU	DASHAVA	E_UKRAIN	PUNGA	BAZAY	GAZLI	ACHAK
LENINGRAD	19	18	20	24	17	19	19	15	17	22	31	21	16	31	33	35	32
NOVGOROD	17	16	18	22	15	17	17	13	15	20	29	19	14	29	31	33	30
VOLOGDA	11	17	19	23	11	13	16	12	14	16	30	20	15	25	27	32	29
SYKTYVKAR	5	25	27	31	19	21	24	20	22	24	38	29	23	33	35	40	37
MOSCOW	17	11	13	17	12	14	12	8	10	17	24	14	9	26	28	28	25
YAROSLAVL	13	15	17	21	9	11	14	10	12	14	28	18	13	23	25	30	27
VLADIMIR	15	13	15	19	9	11	14	10	12	14	25	16	11	23	25	30	27
IVANOVO	14	14	16	20	8	10	13	9	11	13	27	17	12	22	24	29	26
KALININ	16	13	15	19	13	15	14	10	12	18	26	16	11	27	29	30	27
KALUGA	19	12	14	18	14	16	14	10	12	19	25	13	8	28	30	30	27
KOSTROMA	14	15	17	21	9	11	14	10	12	14	28	18	13	23	25	30	27
RYAZAN	19	12	14	18	13	15	10	6	8	18	25	16	11	27	30	26	23
TULA	19	9	11	15	14	16	13	9	11	19	22	15	7	28	30	29	26
KAZAN	20	20	22	26	3	5	14	10	12	8	33	23	18	17	19	27	24
GORKIY	16	16	18	22	6	8	11	7	9	11	29	19	14	20	22	27	24
YOSHKAR_OLA	19	19	21	25	5	7	14	10	12	10	32	22	17	19	21	29	26
SARANSK	18	19	21	25	9	11	8	4	16	14	32	27	17	23	25	24	21
CHEBOKSARY	18	18	20	24	4	6	13	9	11	9	31	21	16	18	20	28	25
BELGOROD	25	7	9	13	20	22	20	16	18	25	20	12	2	34	36	36	33
VORONEZH	22	6	8	12	17	19	16	12	14	22	19	14	4	31	33	32	29
KURSK	24	8	10	14	19	21	19	15	17	24	21	14	4	33	35	35	32
OREL	22	10	12	16	17	19	18	14	16	22	23	12	5	31	33	34	31
BRYANSK	21	11	13	17	16	18	16	12	14	21	24	11	6	30	32	32	29
LIPETSK	22	8	10	14	17	19	16	12	14	22	21	16	6	31	33	32	29
TAMBOV	22	15	17	21	17	19	8	4	6	22	28	19	14	31	28	24	21
PENZA	20	20	22	26	10	12	7	2	4	15	33	24	19	24	25	22	19
VOLGOGRAD	26	22	24	28	16	18	8	4	2	21	35	26	21	30	28	24	21
KUYBYSHEV	27	22	24	29	17	19	1	4	6	22	35	25	21	31	26	22	19
SARATOV	23	18	20	24	13	15	4	1	2	18	31	22	17	27	24	20	17
ROSTOV	27	1	3	8	21	23	20	16	18	26	14	14	4	35	37	36	33
KRASNODAR	29	1	5	10	24	26	23	19	21	29	17	17	7	38	40	39	36
STAVROPOL	30	4	1	4	25	27	24	20	22	30	11	18	7	39	41	40	37
NALCHIK	33	8	3	3	28	30	27	23	25	33	10	21	10	42	44	43	40
ORDZHONIKIDZE	34	9	4	1	29	31	28	24	26	34	7	21	11	43	45	44	41
GROZNYY	34	9	4	1	29	31	28	24	26	34	8	21	11	43	45	44	41
KIEV	26	10	12	16	21	23	21	17	19	26	23	6	4	35	37	37	34
ZAPOROZHYE	30	8	10	14	23	25	22	18	20	29	21	13	3	38	39	38	35
KHARKOV	27	6	8	12	20	22	19	15	17	25	19	11	1	34	36	35	32
LVOV	32	16	18	22	27	29	27	23	25	32	29	1	11	41	43	43	40
KISHINEV	35	13	15	19	28	30	27	23	25	32	26	18	8	41	44	43	40
TALLIN	22	21	23	27	20	22	22	18	20	25	34	24	19	34	36	38	35
RIGA	42	26	28	32	37	39	37	33	35	42	39	10	20	51	53	53	50
VILNIJS	39	23	25	29	35	37	35	31	33	40	35	7	17	49	51	51	48

DISTANCES TO 1970 GAS SOURCES IN 100 KM

NODE	KOMI	KRASNODOR	STAVROPL	GROZNYY	TATAR	BASHKIR	KUYBYSHV	SARATOV	VOLGOGRD	PERM	BAKU	DASHAVA	E_UKRAIN	PUNGA	BAZAY	GAZLI	ACHAK
SMOLENSK	23	13	15	19	18	20	18	14	16	23	26	13	8	32	34	34	31
MINSK	39	23	25	29	34	36	34	30	32	39	36	7	17	48	50	50	47
TBILISI	36	11	6	3	31	33	30	26	28	36	5	23	13	45	47	46	43
BAKU	41	16	11	8	36	38	35	31	33	41	1	28	18	50	52	51	48
YEREVAN	39	14	9	6	34	36	33	29	31	39	6	26	16	48	50	49	46
LUTSK	34	18	20	24	29	31	29	25	27	34	31	3	13	43	45	45	42
ROVNO	34	18	20	24	29	31	29	25	27	34	31	3	13	43	45	45	42
UZHGOROD	33	17	19	23	28	30	28	24	26	33	30	1	12	42	44	44	41
IVANO_FRANKOVSK	32	16	18	22	27	29	27	23	25	32	29	1	12	41	43	43	40
TERNOPOL	30	14	16	20	25	27	24	20	22	30	27	2	9	39	41	40	37
ZHITOMIR	28	12	14	18	23	25	23	19	21	28	25	5	6	37	39	39	36
VINNITSA	29	13	15	19	24	26	24	20	22	29	26	5	7	38	40	40	37
KHMELNITSKIY	29	13	15	19	24	26	24	20	22	29	26	3	8	38	40	40	37
CHERNOVSTY	33	17	19	23	28	30	28	24	26	33	30	3	13	42	44	44	41
CHERNIGOV	24	12	14	18	19	21	17	15	17	24	25	8	6	33	35	35	32
SUMY	33	8	10	14	23	25	22	18	20	28	21	10	3	37	39	38	35
POLTAVA	29	7	9	13	22	24	21	17	19	27	20	9	1	36	38	37	34
CHERKASSY	32	10	12	16	25	27	24	20	22	30	23	8	4	39	41	40	37
ODESSA	33	11	13	17	26	28	25	21	23	31	24	16	6	40	42	41	38
NIKOLAYEV	32	10	12	16	25	27	24	20	22	30	23	15	5	39	41	40	37
KHERSON	32	10	12	16	25	27	24	20	22	30	23	15	5	39	41	40	37
DNEPROPETROVSK	29	7	9	13	22	24	21	17	19	27	20	12	2	36	38	37	34
DONETSK	29	4	5	9	24	26	20	16	18	29	16	13	2	38	40	36	33
VOROSHILOVGRAD	25	3	4	9	21	23	19	15	17	26	16	13	2	35	37	35	32
GRODNO	39	23	25	29	34	36	34	30	32	39	36	7	17	48	50	50	47
GOMEL	25	13	15	19	20	22	20	16	18	25	26	10	8	34	36	36	33
BREST	36	20	22	26	31	33	31	27	29	36	33	4	14	45	47	47	44
UFA	26	26	28	32	3	3	20	16	18	8	39	29	24	17	13	22	19
IZHEVSK	26	26	28	32	2	4	20	16	18	7	39	28	24	12	19	28	25
PERM	28	28	30	34	5	7	22	18	20	1	41	31	27	9	18	28	25
SVERDLOVSK	34	34	36	40	11	10	28	24	26	6	47	37	33	9	13	22	19
CHELYABINSK	33	33	35	39	10	8	27	23	25	8	46	36	32	11	11	20	17
GURYEV	31	26	28	32	21	23	10	8	10	26	39	30	26	29	18	15	12
AKTYUBINSK	35	35	37	41	12	10	29	25	27	15	48	38	34	18	7	15	12
KUSTANAY	32	32	34	38	10	7	27	23	25	13	45	36	32	16	11	20	17
CHIMKENT	53	48	50	54	34	32	31	29	31	37	61	51	46	40	18	9	12
DZHAMBUL	55	50	52	56	36	34	33	31	33	39	63	53	48	42	20	10	13
ALMA_ATA	59	54	56	60	40	38	37	35	37	43	67	57	52	46	24	13	16
TASHKENT	52	47	49	53	33	31	30	28	30	36	60	50	45	39	17	8	11
FRUNZE	57	52	54	58	38	36	35	33	35	41	65	55	50	44	22	11	14

DISTANCES TO 1975 GAS SOURCES IN 100 KM

NODE	KOMI	KRASNODR	STAVROPL	GROZNYY	TATAR	BASHKIR	KUYBYSHV	SARATOV	VULGOGRO	PERM	BAKU	DASHAVA	F_UKRAIN	PUNGA	BAZAY	GAZLI	ACHAK	NADYM	UZEN	KUM_DAG	MARY	ORENBURG
LENINGRAD	19	18	20	24	17	19	19	15	17	22	31	20	16	31	33	35	32	37	28	33	37	22
NOVGOROD	17	16	18	22	15	17	17	13	15	20	29	18	14	29	31	33	30	36	26	31	35	20
VOLOGDA	11	17	19	23	11	13	16	12	14	16	30	19	15	25	27	32	29	31	25	30	34	16
SYKTYVKAR	5	25	27	31	19	21	24	20	22	24	38	27	23	33	35	40	37	39	33	38	42	24
MOSCOW	17	11	13	17	12	14	12	8	10	17	24	14	9	25	28	28	25	31	21	26	30	16
YAROSLAVL	13	15	17	21	9	11	14	10	12	14	28	18	13	23	25	30	27	29	23	28	32	14
VLADIMIR	15	13	15	19	9	11	14	10	12	14	26	16	11	23	25	30	27	29	23	28	32	14
IVANOVO	14	14	16	20	8	10	13	9	11	13	27	17	12	22	24	29	25	28	22	27	31	13
KALININ	16	13	15	19	13	15	14	10	12	18	26	13	11	27	29	30	27	33	23	28	32	18
KALUGA	19	12	14	18	14	16	14	10	12	19	25	13	8	28	30	30	27	34	23	28	32	18
KOSTROMA	14	15	17	21	9	11	14	10	12	14	28	18	13	23	25	30	27	29	23	28	32	14
RYAZAN	19	12	14	18	13	15	10	6	8	18	25	16	11	27	30	26	23	33	19	24	28	14
TULA	19	9	11	15	14	16	13	9	11	19	22	15	7	28	30	29	26	34	22	27	31	17
KAZAN	20	20	22	26	3	5	14	10	12	8	33	23	18	17	19	27	24	23	20	25	29	8
GORKIY	16	16	18	22	6	8	11	7	9	11	29	19	14	20	22	27	24	26	20	25	29	11
YOSHKAR_OLA	19	19	21	25	5	7	14	10	12	10	32	22	17	19	21	29	25	25	22	27	31	10
SARANSK	18	16	18	22	9	11	8	4	16	14	29	22	13	23	25	24	21	29	17	22	26	12
CHEBOKSARY	18	18	20	24	4	6	13	9	11	9	31	21	16	18	20	28	25	24	21	26	30	9
BELGOROD	25	7	9	13	20	21	13	9	11	25	20	12	2	34	30	28	25	40	21	25	30	17
VORONEZH	22	6	8	12	17	19	11	7	9	22	19	14	4	31	28	25	22	37	19	24	27	15
KURSK	24	8	10	14	19	21	15	11	13	24	21	14	4	33	32	30	27	39	23	28	32	19
OREL	22	10	12	16	17	19	16	12	14	22	23	12	5	31	33	31	28	37	24	29	33	20
BRYANSK	21	11	13	17	16	18	16	12	14	21	24	11	6	30	32	32	29	36	25	30	34	20
LIPETSK	22	8	10	14	17	19	13	9	11	22	21	16	6	31	30	28	25	37	21	26	30	17
TAMBOV	22	15	17	21	17	19	8	4	6	22	28	19	14	31	28	24	21	37	17	22	26	12
PENZA	20	14	16	20	10	12	7	2	4	15	28	20	12	24	25	23	20	30	15	20	24	11
VOLGOGRAD	26	14	18	22	17	16	8	4	2	21	29	23	11	30	26	23	20	36	16	21	25	12
KUYBYSHEV	27	16	18	22	9	8	1	4	6	14	29	22	13	23	18	22	19	29	15	20	24	4
SARATOV	23	12	14	18	13	12	4	1	2	18	25	18	9	27	22	20	17	33	13	18	22	8
ROSTOV	27	1	3	8	21	21	14	10	12	26	14	14	4	35	31	29	26	41	22	27	31	18
KRASNODAR	29	1	5	10	24	24	16	12	14	29	17	17	7	38	33	31	28	44	24	29	33	20
STAVROPOL	30	4	1	4	25	26	18	14	16	30	11	18	7	39	35	33	30	45	26	31	35	21
NALCHIK	33	8	3	3	28	29	21	17	19	33	10	21	10	42	38	36	33	46	29	34	38	25
ORDZHONIKIDZE	34	9	4	1	29	30	22	18	20	34	7	21	11	43	39	37	34	49	30	35	39	26
GROZNYY	34	9	4	1	29	30	22	18	20	34	8	21	11	43	39	37	34	49	30	35	39	25
KIEV	26	10	12	16	21	23	17	13	15	26	23	6	4	35	34	32	29	41	25	30	34	21
ZAPOROZHYE	30	8	10	14	23	23	15	11	13	29	21	13	3	39	33	30	27	44	22	27	32	19
KHARKOV	27	6	8	12	20	20	13	8	10	25	19	11	1	34	29	27	24	40	20	25	29	16
LVOV	29	16	18	22	27	29	23	19	21	32	29	1	11	37	40	38	35	43	31	35	40	27
KISHINEV	35	13	15	19	28	28	20	16	18	32	26	18	8	41	37	35	32	47	28	33	36	24
TALLIN	22	21	23	27	20	22	22	18	20	25	34	24	19	34	36	38	35	40	31	36	40	25
RIGA	28	23	25	29	26	28	27	23	35	31	36	10	18	38	42	43	40	44	36	41	45	31
VILNIUS	25	20	22	26	23	25	24	20	22	28	33	7	15	35	39	40	37	41	33	38	42	28

DISTANCES TO 1975 GAS SOURCES IN 100 KM

NODE	KOMI	KRASNODR	STAVROPL	GROZNYY	TATAR	BASHKIR	KUYBYSHV	SARATOV	VOLGOGRJ	PERM	BAKU	DASHAVA	E_UKRAIN	PUNGA	BAZAY	GAZLI	ACHAK	NADYH	UZEN	KUM_DAG	MARY	ORENBURG
SMOLENSK	18	13	15	19	16	18	17	13	15	21	26	10	8	28	32	33	30	34	26	31	35	21
MINSK	21	16	18	22	19	21	20	16	18	24	29	7	11	31	35	36	33	37	29	34	38	24
TBILISI	36	11	6	3	31	31	24	20	22	36	5	23	13	45	41	39	36	41	32	37	41	28
BAKU	41	15	11	8	36	37	29	25	27	41	1	28	18	50	46	44	41	56	37	42	45	33
YEREVAN	39	14	9	6	34	36	30	26	28	39	6	26	16	48	47	45	42	54	38	43	47	34
LUTSK	27	18	20	24	25	27	25	21	23	30	31	3	13	37	42	40	37	43	33	38	42	29
ROVNO	31	18	20	24	29	31	25	21	23	34	31	3	13	39	42	40	37	49	33	38	42	29
UZHGOROD	31	17	19	23	28	30	24	20	22	33	30	1	12	42	41	39	36	48	32	37	41	28
IVANO_FRANKOVSK	31	16	18	22	27	29	23	19	21	22	29	1	12	41	40	38	35	47	31	36	40	27
TERNOPOL	30	14	16	20	25	27	20	16	18	30	27	2	9	39	37	35	32	45	28	33	37	24
ZHITOMIR	28	12	14	18	23	25	19	15	17	28	25	5	6	37	36	34	31	43	27	32	36	23
VINNITSA	29	13	15	19	24	26	20	16	18	29	26	5	7	38	37	35	32	44	28	33	37	24
KHMELNITSKIY	29	13	15	19	24	26	20	16	18	29	26	3	8	38	37	35	32	44	28	33	37	24
CHERNOVSTY	32	17	19	23	28	30	24	20	22	33	30	3	13	42	41	29	26	48	22	27	31	28
CHERNIGOV	24	12	14	18	19	21	19	15	17	24	25	8	6	33	35	35	32	39	28	33	37	23
SUMY	30	8	10	14	23	23	15	11	13	28	21	10	3	37	32	30	27	43	23	28	32	19
POLTAVA	29	7	9	13	22	22	14	10	12	27	20	9	1	36	31	29	26	42	22	27	31	18
CHERKASSY	32	10	12	16	25	25	17	13	15	30	23	8	4	39	34	32	29	45	25	30	34	21
ODESSA	33	11	13	17	26	26	18	14	16	31	24	16	6	40	35	33	30	46	26	31	35	22
NIKOLAYEV	32	10	12	16	25	25	17	13	15	30	23	15	5	39	34	32	29	45	25	30	34	21
KHERSON	32	10	12	16	25	25	17	13	15	30	23	15	5	39	34	32	29	45	25	30	34	21
DNEPROPETROVSK	29	7	9	13	22	22	14	10	12	27	20	12	2	36	31	29	26	42	22	27	31	18
DONETSK	29	4	5	9	24	24	15	12	14	29	15	13	2	38	33	31	28	44	24	29	33	20
VOROSHILOVGRAD	26	3	4	9	21	21	13	9	11	26	16	13	2	35	30	28	25	41	21	26	30	17
GRODNO	25	20	22	26	23	25	24	20	22	28	33	7	15	35	39	40	37	41	33	38	42	28
VITEBSK	20	15	17	21	18	20	19	15	17	23	28	10	10	32	34	35	32	40	28	33	37	23
MOGILEV	20	15	17	21	18	20	19	15	17	23	28	10	10	32	34	35	32	40	28	33	37	23
GOMEL	25	13	15	19	20	22	20	16	18	25	26	10	8	34	36	36	33	40	29	34	38	24
BREST	24	20	22	26	23	25	24	20	22	28	32	4	14	34	39	40	37	40	33	38	42	28
UFA	26	24	26	30	3	3	8	12	14	8	37	29	21	17	13	22	19	23	21	26	24	4
IZHEVSK	26	26	28	32	2	4	12	16	18	2	39	28	24	12	19	28	25	18	25	30	30	7
ORENBURG	31	19	21	25	5	4	4	9	10	10	33	26	17	19	14	23	20	25	19	24	25	1
PERM	28	28	30	34	5	7	14	18	20	1	41	31	27	9	18	28	25	15	27	32	30	10
SVERDLOVSK	34	30	32	36	11	10	14	18	20	6	43	36	27	9	13	22	19	15	29	34	24	10
CHELYABINSK	33	28	30	34	10	8	12	16	18	8	41	34	25	11	11	20	17	17	27	32	22	8
GURYEV	31	19	21	25	21	23	10	8	10	26	32	25	16	29	18	15	12	35	7	12	17	14
AKTYUBINSK	35	30	32	36	12	10	14	18	20	15	43	36	26	18	7	15	12	24	22	27	17	10
KUSTANAY	32	28	30	34	10	7	12	16	18	13	41	34	24	16	11	20	17	22	27	32	22	8
CHIMKENT	53	40	42	46	34	32	31	29	31	37	54	46	38	40	18	9	12	46	22	27	17	32
DZHAMBUL	55	42	44	49	36	33	33	31	33	39	56	48	40	42	20	10	13	48	23	28	18	33
ALMA_ATA	59	46	48	52	40	38	37	35	37	43	60	52	44	46	24	13	16	52	26	31	21	36
ASHKHABAD	50	37	39	43	31	29	28	26	28	34	51	43	35	37	15	12	9	43	19	24	5	29
DUSHANBE	51	38	40	44	32	30	29	27	29	35	52	44	36	38	16	7	10	44	20	25	15	30

DISTANCES TO 1975 GAS SOURCES IN 100 KM

NODE	KOMI	KRASNODR	STAVROPL	GROZNYY	TATAR	BASHKIR	KUYBYSHV	SARATOV	VOLGOGRD	PERM	BAKU	DASHAVA	E UKRAIN	PUNGA	BAZAY	GAZLI	ACHAK	NADYM	UZEN	CJM DAG	MARY	ORENBURG
TASHKENT	52	39	41	45	33	31	30	28	30	36	53	45	37	39	17	8	11	45	21	26	16	31
FRUNZE	57	44	46	50	38	36	35	33	35	41	58	50	42	44	22	11	14	50	24	29	19	34

APPENDIX D

COAL, OIL, AND NATURAL GAS POTENTIAL INDICES BASED ON DISTANCE AND TRANSPORT COSTS

COAL, OIL, AND GAS POTENTIAL INDICES BASED ON DISTANCE

NODE	CP60	OP60	GP60	CP70	OP70	GP70	CP75	OP75	GP75
LENINGRAD	17	11	2	18	25	11	19	32	14
MURMANSK	11	7	0	12	17	0	13	22	0
PETROZAVODSK	15	10	0	16	23	0	17	29	0
NOVGOROD	19	11	3	19	27	12	20	33	16
VOLOGDA	20	14	0	21	33	12	22	41	17
ARKHANGELSK	14	10	0	16	23	0	17	29	0
SYKTYVKAR	15	10	0	17	26	9	18	35	15
MOSCOW	30	17	4	31	38	17	31	47	21
YAROSLAVL	22	16	0	23	37	13	24	46	18
VLADIMIR	23	20	0	25	44	15	26	52	19
IVANOVO	21	18	0	23	41	14	23	49	19
KALININ	23	15	3	24	34	14	25	41	19
KALUGA	38	15	4	37	35	17	37	43	21
KOSTROMA	21	16	0	22	37	13	23	46	18
RYAZAN	28	18	4	30	40	15	31	48	20
TULA	41	16	4	40	37	19	40	44	23
KAZAN	20	53	3	22	113	13	23	126	19
GORKIY	21	24	3	22	53	14	23	63	19
KIROV	19	17	0	21	41	0	22	53	0
YOSHKAR_OLA	19	33	0	21	71	12	22	83	18
SARANSK	23	26	3	25	54	12	26	64	19
CHEBOKSARY	21	34	3	23	72	13	24	83	19
ULYANOVSK	21	47	0	23	96	0	25	108	0
BELGOROD	46	13	8	50	37	40	51	43	50
VORONEZH	36	16	6	39	38	27	40	45	33
KURSK	37	14	5	40	36	25	41	43	30
OREL	34	14	4	36	35	21	36	42	26
BRYANSK	31	14	4	33	34	19	34	42	24
LIPETSK	35	17	0	37	39	20	37	46	25
TAMBOV	31	20	0	33	44	14	33	52	18
PENZA	25	28	4	27	58	14	28	67	21
ASTRAKHAN	21	19	0	25	43	1	26	49	1
VOLGOGRAD	36	22	4	39	46	13	40	53	21
KUYBYSHEV	22	72	1	24	139	14	26	154	26
SARATOV	25	37	7	27	69	18	28	79	26
ROSTOV	98	16	12	104	36	55	105	40	42
KRASNODAR	33	23	10	35	39	46	37	44	32
STAVROPOL	33	16	13	36	34	40	37	38	36
MAKHACHKALA	20	20	0	22	51	2	23	49	1
NALCHIK	24	18	0	26	45	21	27	44	22
ORDZHONIKIDZE	24	20	5	26	60	22	27	51	24
GROZNYY	22	22	5	24	65	22	25	56	23
KIEV	30	11	3	33	34	25	34	41	30
ZAPOROZHYE	55	12	0	60	30	29	61	35	36
KHARKOV	56	14	14	62	37	70	62	44	87
LVOV	21	12	8	29	25	25	31	29	23
KISHINEV	21	9	0	23	22	14	24	26	18
TALLIN	15	9	2	17	22	9	17	28	13
RIGA	16	10	0	18	23	8	19	29	12
VILNIUS	18	10	0	20	24	10	21	30	14
KALININGRAD	15	9	0	17	20	0	18	26	0
SMOLENSK	24	13	0	26	31	16	27	39	20
PSKOV	17	11	0	19	25	0	20	32	0
MINSK	21	11	2	23	28	10	24	35	17
TBILISI	17	14	1	19	27	16	20	31	19
BAKU	16	36	7	18	58	16	19	58	24

COAL, OIL, AND GAS POTENTIAL INDICES BASED ON DISTANCE

NODE	CP60	OP60	GP60	CP70	OP70	GP70	CP75	OP75	GP75
YEREVAN	14	11	1	15	23	12	16	27	15
LUTSK	21	10	0	26	24	15	27	29	16
ROVNO	22	10	0	27	25	15	29	31	16
UZHGOROD	18	10	0	21	22	25	22	26	22
IVANO_FRANKOVSK	19	11	0	23	25	25	25	29	22
TERNOPOL	21	10	5	26	24	20	27	29	21
ZHITOMIR	25	11	3	28	27	20	29	33	23
VINNITSA	23	10	3	26	26	18	29	32	21
KHMELNITSKIY	22	10	0	25	25	19	27	30	21
CHERNOVSTY	19	10	0	22	22	15	23	27	17
CHERNIGOV	28	12	0	30	38	19	31	49	23
SUMY	34	13	0	37	44	30	38	50	36
POLTAVA	46	13	0	50	43	69	51	49	86
CHERKASSY	40	11	0	43	32	24	44	38	29
KIROVOGRAD	32	11	0	34	29	0	35	35	0
ODESSA	24	10	0	27	24	18	29	29	22
NIKOLAYEV	32	11	0	35	28	20	36	33	25
KHERSON	32	11	0	35	28	20	36	33	25
SIMFEROPOL	31	11	0	34	26	0	35	30	0
DNEPROPETROVSK	56	12	8	61	32	40	62	37	49
DONETSK	150	14	0	163	33	45	164	39	51
VOROSHILOVGRAD	163	14	7	175	33	49	176	39	54
GRODNO	17	9	0	19	23	10	20	28	14
VITEBSK	22	12	0	24	29	0	24	37	18
MOGILEV	24	12	0	26	31	0	27	40	18
GOMEL	26	12	0	28	34	16	29	45	19
BREST	19	10	3	23	24	13	24	30	15
UFA	20	51	2	22	102	11	24	116	22
IZHEVSK	20	32	0	21	72	12	22	89	20
ORENBURG	18	29	1	21	61	2	22	74	40
PERM	24	35	0	24	89	11	25	112	17
SVERDLOVSK	23	18	0	24	45	9	26	64	16
CHELYABINSK	29	21	0	30	49	9	32	64	18
TYUMEN	19	14	0	22	37	0	24	58	0
KURGAN	22	17	0	25	40	0	27	59	0
OMSK	21	12	0	25	28	0	29	44	0
NOVOSIBIRSK	34	8	0	43	20	0	51	40	0
TOMSK	33	7	0	42	18	0	49	47	0
BARNAUL	25	8	0	31	18	0	37	33	0
KRASNOYARSK	24	6	0	32	15	0	40	31	0
IRKUTSK	23	5	0	26	11	0	26	20	0
CHITA	12	4	0	14	9	0	17	15	0
ABAKAN	22	6	0	28	15	0	32	27	0
KEMEROVO	79	7	0	100	18	0	119	38	0
ULAN_UDE	12	4	0	14	10	0	16	17	0
VLADIVOSTOK	10	3	0	13	6	0	14	9	0
KHABAROVSK	7	3	0	8	7	0	9	10	0
BLAGOVESHCHENSK	8	3	0	9	7	0	10	11	0
YUZHNO_SAKHALINSK	7	2	0	8	6	0	8	9	0
MAGADAN	5	3	0	6	6	0	7	9	0
YAKUTSK	7	3	0	8	7	0	9	10	0
PETROPAVLOVSK_KAM	5	2	0	6	6	0	6	8	0
GURYEV	14	14	0	22	39	11	23	48	20
AKTYUBINSK	18	19	0	20	44	9	22	55	18
URALSK	20	22	0	22	46	0	23	56	0
KUSTANAY	23	17	0	25	38	9	27	51	17

COAL, OIL, AND GAS POTENTIAL INDICES BASED ON DISTANCE

NODE	CP60	OP60	GP60	CP70	OP70	GP70	CP75	GP75	GP75
PETROPAVLOVSK	21	14	0	25	33	0	29	47	0
KOKCHETAV	20	12	0	25	29	0	29	42	0
TSELINOGRAD	24	11	0	32	25	0	39	36	0
KARAGANDA	37	10	0	49	23	0	58	32	0
KZYL_ORDA	13	11	0	15	24	0	17	31	0
CHIMKENT	14	9	0	16	20	9	18	27	15
DZHAMBUL	13	8	0	16	19	8	18	25	14
SEMIPALATINSK	17	7	0	21	16	0	25	25	0
PAVLODAR	24	8	0	38	20	0	54	32	0
UST_KAMENOGORSK	17	7	0	21	16	0	25	24	0
ALMA_ATA	13	7	0	16	16	7	18	22	12
ASHKHABAD	12	11	0	14	24	0	15	29	19
DUSHANBE	9	7	0	11	15	1	12	19	18
TASHKENT	14	9	0	17	20	10	19	26	16
FRUNZE	12	8	0	15	17	9	17	24	13
NORILSK	2	0	0	2	0	0	2	0	1
ELISTA	24	13	0	26	28	0	27	32	0

COAL, OIL, AND GAS POTENTIAL INDICES BASED ON TRANSPORT COSTS

NODE	CP60	OP60	GP60	CP70	OP70	GP70	CP75	OP75	GP75
LENINGRAD	3	11	1	4	25	3	4	32	4
MURMANSK	2	7	0	2	17	0	3	22	0
PETROZAVODSK	3	10	0	3	23	0	3	29	0
NOVGOROD	4	11	1	4	27	3	4	33	4
VOLOGDA	4	14	0	4	33	3	4	41	4
ARKHANGELSK	3	10	0	3	23	0	3	29	0
SYKTYVKAR	3	10	0	3	26	2	4	35	4
MOSCOW	6	17	1	6	39	4	6	47	5
YAROSLAVL	4	16	0	5	37	3	5	46	5
VLADIMIR	5	20	0	5	44	4	5	52	5
IVANOVO	4	18	0	5	41	4	5	49	5
KALININ	5	15	1	5	34	4	5	41	5
KALUGA	9	15	4	7	35	4	7	42	5
KOSTROMA	4	16	0	4	37	3	5	46	5
RYAZAN	6	18	1	6	40	4	6	48	5
TULA	8	16	1	8	37	5	8	44	6
KAZAN	4	53	1	4	113	3	5	126	5
GORKIY	4	24	1	4	53	4	5	63	5
KIROV	4	17	0	4	41	0	4	53	0
YOSHKAR_OLA	4	33	0	4	71	3	4	83	5
SARANSK	5	26	1	5	54	3	5	64	5
CHEBOKSARY	4	34	1	5	72	3	5	83	5
ULYANOVSK	4	47	0	5	96	0	5	108	0
BELGOROD	9	13	2	10	37	10	10	43	13
VORONEZH	7	16	2	8	38	7	8	45	8
KURSK	7	14	1	8	36	6	8	43	8
OREL	7	14	1	7	35	5	7	42	7
BRYANSK	6	14	1	7	34	5	7	42	6
LIPETSK	7	17	0	7	39	5	7	46	6
TAMBOV	6	20	0	7	44	4	7	52	5
PENZA	5	28	1	5	58	4	6	67	5
ASTRAKHAN	4	19	0	5	43	0	5	49	0
VOLGOGRAD	7	22	1	8	46	3	8	53	5
KUYBYSHEV	4	72	0	5	139	4	5	154	7
SARATOV	5	37	2	5	69	5	6	79	7
ROSTOV	20	16	3	21	36	14	21	40	11
KRASNODAR	7	23	3	7	39	12	7	44	8
STAVROPOL	7	16	3	7	34	10	7	38	9
MAKHACHKALA	4	20	0	4	51	1	5	49	0
NALCHIK	5	18	0	5	45	5	5	44	6
ORDZHONIKIDZE	5	20	1	5	60	6	5	51	6
GROZNYY	4	22	1	5	65	6	5	56	6
KIEV	6	11	1	7	34	6	7	41	8
ZAPOROZHYE	11	12	0	12	30	7	12	35	9
KHARKOV	11	14	4	12	37	18	12	44	22
LVOV	4	12	2	6	25	6	6	29	6
KISHINEV	4	9	0	5	22	4	5	26	5
TALLIN	3	9	1	3	22	2	3	28	3
RIGA	3	10	0	4	23	2	4	29	3
VILNIUS	4	10	0	4	24	3	4	30	4
KALININGRAD	3	9	0	3	20	0	4	26	0
SMOLENSK	5	13	0	5	31	4	5	39	5
PSKOV	3	11	0	4	25	0	4	32	0
MINSK	4	11	1	5	28	3	5	35	4
TBILISI	3	14	0	4	27	4	4	31	5
BAKU	3	36	2	4	[illegible]	4	4	58	6

COAL, OIL, AND GAS POTENTIAL INDICES BASED ON TRANSPORT COSTS

NODE	CP60	OP60	GP60	CP70	OP70	GP70	CP75	OP75	GP75
YEREVAN	3	11	0	3	23	3	3	27	4
LUTSK	4	10	0	5	24	4	5	29	4
ROVNO	4	10	0	5	25	4	6	31	4
UZHGOROD	4	10	0	4	22	6	4	26	6
IVANO_FRANKOVSK	4	11	0	5	25	6	5	28	6
TERNOPOL	4	10	1	5	24	5	5	29	5
ZHITOMIR	5	11	1	6	27	5	6	33	6
VINNITSA	5	10	1	5	26	5	6	32	5
KHMELNITSKIY	4	10	0	5	25	5	5	30	5
CHERNOVSTY	4	10	0	4	22	4	5	27	4
CHERNIGOV	6	12	0	6	38	5	6	49	6
SUMY	7	13	0	7	44	8	8	50	9
POLTAVA	9	13	0	10	43	17	10	49	22
CHERKASSY	8	11	0	9	32	6	9	38	7
KIROVOGRAD	6	11	0	7	29	0	7	35	0
ODESSA	5	10	0	5	24	5	6	29	6
NIKOLAYEV	6	11	0	7	28	5	7	33	6
KHERSON	6	11	0	7	28	5	7	33	6
SIMFEROPOL	6	11	0	7	26	0	7	30	0
DNEPROPETROVSK	11	12	2	12	32	10	12	37	12
DONETSK	30	14	0	33	33	11	33	39	13
VOROSHILOVGRAD	33	14	2	35	33	12	35	39	14
GRODNO	3	9	0	4	23	3	4	28	4
VITEBSK	4	12	0	5	29	0	5	37	5
MOGILEV	5	12	0	5	31	0	5	40	5
GOMEL	5	12	0	6	34	4	6	45	5
BREST	4	10	1	5	24	3	5	30	4
UFA	4	51	1	4	102	3	5	116	6
IZHEVSK	4	32	0	4	72	3	4	89	5
ORENBURG	4	29	0	4	61	1	4	74	0
PERM	5	35	0	5	89	3	5	112	4
SVERDLOVSK	5	18	0	5	45	2	5	64	4
CHELYABINSK	6	21	0	6	49	2	6	64	5
TYUMEN	4	14	0	4	37	0	5	58	0
KURGAN	4	17	0	5	40	0	5	59	0
OMSK	4	12	0	5	28	0	6	44	0
NOVOSIBIRSK	7	6	0	9	20	0	10	40	0
TOMSK	7	7	0	8	18	0	10	47	0
BARNAUL	5	8	0	6	18	0	7	33	0
KRASNOYARSK	5	6	0	6	15	0	9	31	0
IRKUTSK	5	5	0	5	11	0	5	20	0
CHITA	2	4	0	3	9	0	3	15	0
ABAKAN	4	6	0	6	15	0	6	27	0
KEMEROVO	16	7	0	20	18	0	24	38	0
ULAN_UDE	2	4	0	3	10	0	3	17	0
VLADIVOSTOK	2	3	0	3	6	0	3	9	0
KHABAROVSK	1	3	0	2	7	0	2	10	0
BLAGOVESHCHENSK	2	3	0	2	7	0	2	11	0
YUZHNO_SAKHALINSK	1	2	0	2	6	0	2	9	0
MAGADAN	1	3	0	1	6	0	1	9	0
YAKUTSK	1	3	0	2	7	0	2	10	0
PETROPAVLOVSK_KAM	1	2	0	1	6	0	1	8	0
GURYEV	3	14	0	4	39	3	5	48	5
AKTYUBINSK	4	19	0	4	44	2	4	55	5
URALSK	4	22	0	4	46	0	5	56	0
KUSTANAY	5	17	0	5	38	2	5	51	4

COAL, OIL, AND GAS POTENTIAL INDICES BASED ON TRANSPORT COSTS

NODE	CP60	OP60	GP60	CP70	OP70	GP70	CP75	OP75	GP75
PETROPAVLOVSK	4	14	0	5	33	0	6	47	0
KOKCHETAV	4	12	0	5	29	0	6	42	0
TSELINOGRAD	5	11	0	6	25	0	9	36	0
KARAGANDA	7	10	0	10	23	0	12	32	0
KZYL_ORDA	3	11	0	3	24	0	3	31	0
CHIMKENT	3	9	0	3	20	2	4	27	4
DZHAMBUL	3	9	0	3	19	2	4	25	4
SEMIPALATINSK	3	7	0	4	16	0	5	25	0
PAVLODAR	5	9	0	8	20	0	11	32	0
UST_KAMENOGORSK	3	7	0	4	16	0	5	24	0
ALMA_ATA	3	7	0	3	16	2	4	22	3
ASHKHABAD	2	11	0	3	24	0	3	29	5
DUSHANBE	2	7	0	2	15	0	2	19	5
TASHKENT	3	9	0	3	20	3	4	26	4
FRUNZE	2	8	0	3	17	2	3	24	3
NORILSK	0	0	0	0	0	0	0	0	0
ELISTA	5	13	0	5	28	0	5	32	0

APPENDIX E

URBAN POPULATION DATA

SOVIET URBAN POPULATION AND GROWTH RATES

NODE	POP59[a]	POP70[a]	POP79[a]	GROWTH1[b]	GROWTH2[c]
LENINGRAD	3003	3550	4073	18	15
MURMANSK	222	309	381	39	23
PETROZAVODSK	141	192	234	37	22
NOVGOROD	61	128	186	111	45
VOLOGDA	139	178	237	28	33
ARKHANGELSK	258	343	385	33	12
SYKTYVKAR	69	125	171	82	37
MOSCOW	6009	6942	7831	16	13
YAROSLAVL	407	517	597	27	15
VLADIMIR	154	234	296	52	26
IVANOVO	335	419	465	25	11
KALININ	261	345	412	32	19
KALUGA	134	211	265	57	26
KOSTROMA	172	223	255	30	14
RYAZAN	214	351	453	64	29
TULA	351	462	514	32	11
KAZAN	667	869	993	30	14
GORKIY	941	1170	1344	24	15
KIROV	252	332	390	32	17
YOSHKAR_OLA	89	166	201	87	21
SARANSK	91	191	263	109	38
CHEBOKSARY	104	216	308	104	43
ULYANOVSK	206	351	464	70	32
BELGOROD	72	151	240	109	59
VORONEZH	407	660	783	48	19
KURSK	205	284	375	39	32
OREL	150	232	305	55	31
BRYANSK	207	318	394	53	24
LIPETSK	157	290	396	85	37
TAMBOV	172	230	270	33	17
PENZA	255	374	483	46	26
ASTRAKHAN	305	410	461	34	12
VOLGOGRAD	591	818	929	38	14
KUYBYSHEV	806	1045	1216	30	16
SARATOV	579	757	856	31	13
ROSTOV	600	789	934	32	18
KRASNODAR	313	464	560	48	21
STAVROPOL	141	198	258	41	30
MAKHACHKALA	119	186	250	56	35
NALCHIK	88	146	207	66	42
ORDZHONIKIDZE	164	236	279	44	18
GROZNYY	250	341	375	37	10
KIEV	1110	1632	2144	47	31
ZAPOROZHYE	449	658	781	46	19
KHARKOV	953	1223	1444	28	18
LVOV	411	553	667	35	21
KISHINEV	216	357	503	65	41
TALLIN	282	363	430	29	19
RIGA	580	732	835	26	14
VILNIUS	236	372	481	58	29
KALININGRAD	204	297	355	46	20
SMOLENSK	147	211	276	43	31
PSKOV	81	127	176	56	39
MINSK	509	907	1262	78	39
TBILISI	703	889	1066	27	20
BAKU	643	852	1022	33	20

SOVIET URBAN POPULATION AND GROWTH RATES

NODE	POP59	POP70	POP79	GROWTH1	GROWTH2
YEREVAN	493	767	1019	55	33
LUTSK	56	94	137	69	46
ROVNO	56	116	179	106	55
UZHGOROD	47	65	91	36	41
IVANO_FRANKOVSK	66	105	150	58	43
TERNOPOL	52	85	144	62	70
ZHITOMIR	106	161	244	52	52
VINNITSA	122	212	313	74	48
KHMELNITSKIY	62	113	172	81	52
CHERNOVSTY	152	187	218	23	17
CHERNIGOV	90	159	238	77	50
SUMY	98	159	223	62	43
POLTAVA	143	220	279	54	27
CHERKASSY	85	158	228	87	44
KIROVOGRAD	132	189	237	43	26
ODESSA	664	892	1046	34	17
NIKOLAYEV	251	362	441	41	22
KHERSON	158	261	319	65	22
SIMFEROPOL	186	249	302	34	21
DNEPROPETROVSK	691	904	1066	30	18
DONETSK	708	879	1021	24	16
VOROSHILOVGRAD	275	383	463	39	21
GRODNO	73	132	195	82	47
VITEBSK	148	231	297	56	29
MOGILEV	122	202	290	66	43
GOMEL	168	272	383	62	41
BREST	74	122	177	65	46
UFA	547	771	969	41	26
IZHEVSK	285	422	549	48	30
ORENBURG	267	344	459	29	33
PERM	629	850	999	35	17
SVERDLOVSK	779	1025	1211	32	18
CHELYABINSK	689	875	1031	27	18
TYUMEN	150	269	359	79	34
KURGAN	146	244	310	67	27
OMSK	581	821	1014	41	23
NOVOSIBIRSK	885	1161	1312	31	13
TOMSK	249	338	421	36	24
BARNAUL	303	439	533	45	21
KRASNOYARSK	412	648	796	57	23
IRKUTSK	366	451	550	23	22
CHITA	172	241	302	40	25
ABAKAN	56	90	128	60	42
KEMEROVO	289	385	471	33	22
ULAN_UDE	174	254	300	45	18
VLADIVOSTOK	291	441	550	52	25
KHABAROVSK	323	436	528	35	21
BLAGOVESHCHENSK	94	128	172	36	35
YUZHNO_SAKHALINSK	86	106	140	24	32
MAGADAN	62	92	122	48	32
YAKUTSK	74	108	152	45	41
PETROPAVLOVSK_KAM	86	154	215	80	40
GURYEV	79	114	130	45	14
AKTYUBINSK	97	150	191	55	27
URALSK	99	134	167	36	24
KUSTANAY	86	123	164	43	33

SOVIET URBAN POPULATION AND GROWTH RATES

NODE	POP59	POP70	POP79	GROWTH1	GROWTH2
PETROPAVLOVSK	131	173	207	32	20
KOKCHETAV	53	81	103	52	29
TSELINOGRAD	99	180	234	82	30
KARAGANDA	383	523	572	37	9
KZYL_ORDA	66	122	156	86	27
CHIMKENT	153	247	321	61	30
DZHAMBUL	113	187	264	65	41
SEMIPALATINSK	156	236	283	51	20
PAVLODAR	90	187	273	108	46
UST_KAMENOGORSK	150	230	274	53	19
ALMA_ATA	456	733	910	60	24
ASHKHABAD	170	253	312	49	23
DUSHANBE	227	374	493	65	32
TASHKENT	927	1385	1779	49	28
FRUNZE	220	431	533	96	24
NORILSK	118	135	180	14	33
ELISTA[d]	•	•	•	•	•

[a]Population in 1959, 1970, and 1979

[b]Percent increase 1959-1970

[c]Percent increase 1970-1979.

[d]Data not available.

Source: Data compiled by Shabad in Bond and Lydolph (1979).